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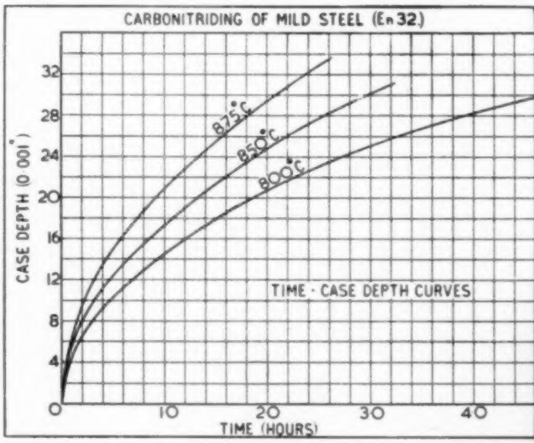

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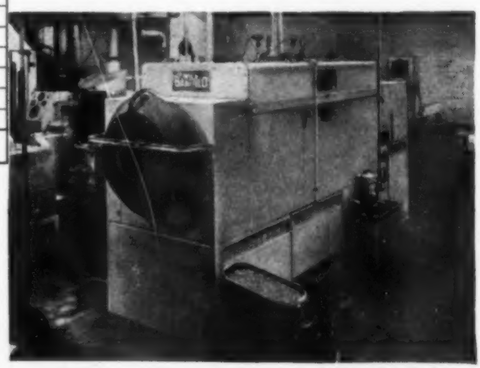

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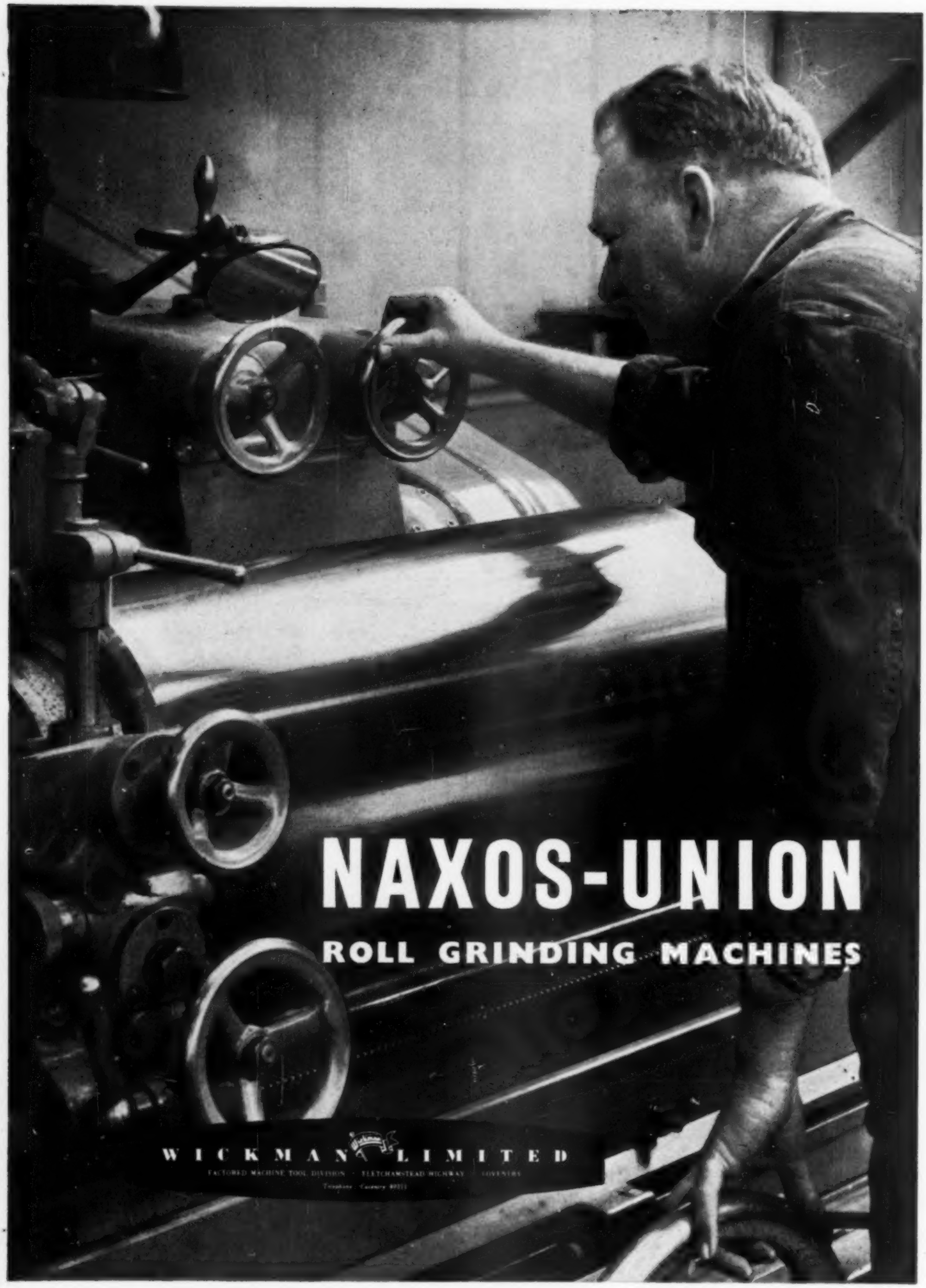
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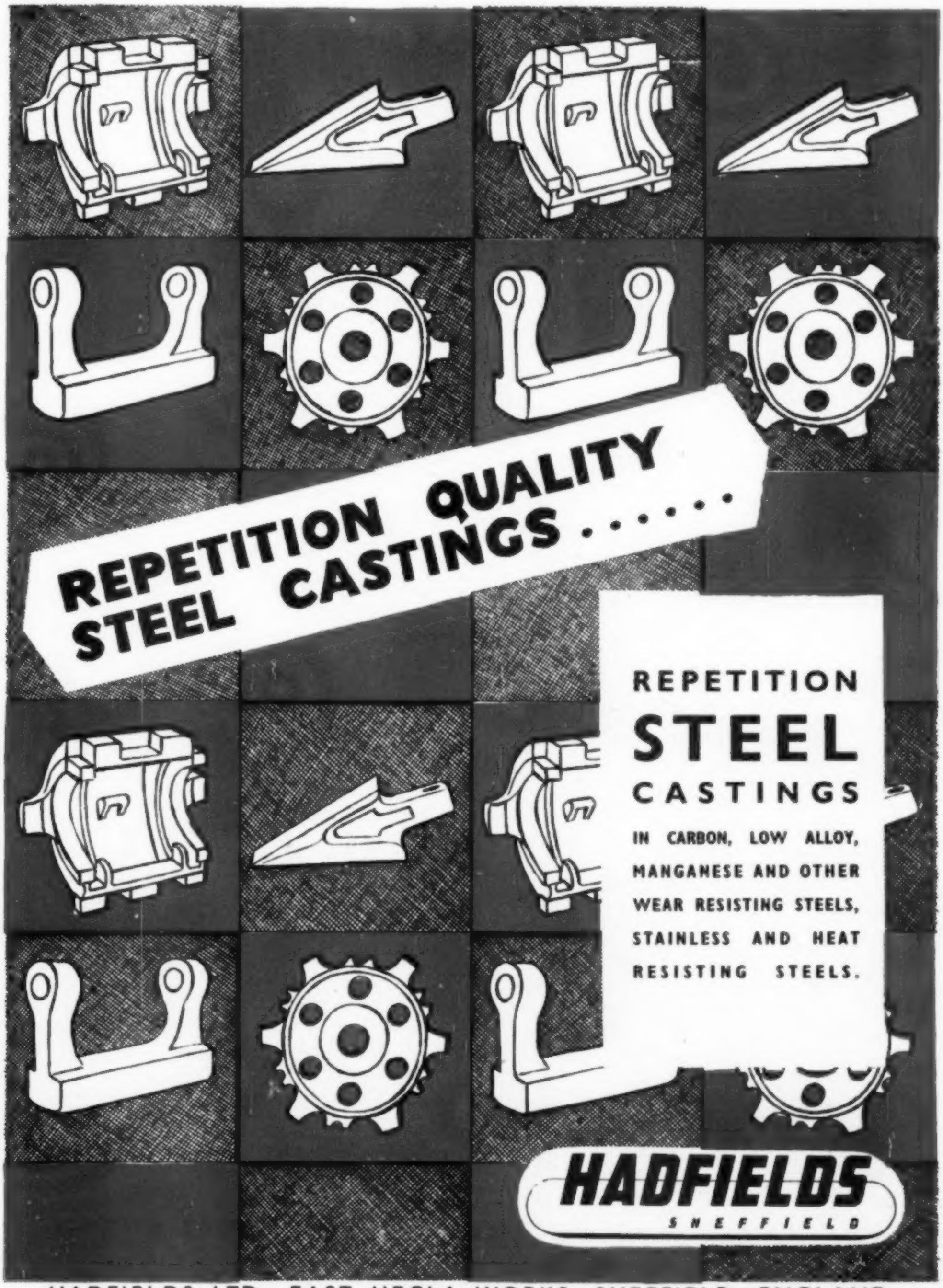
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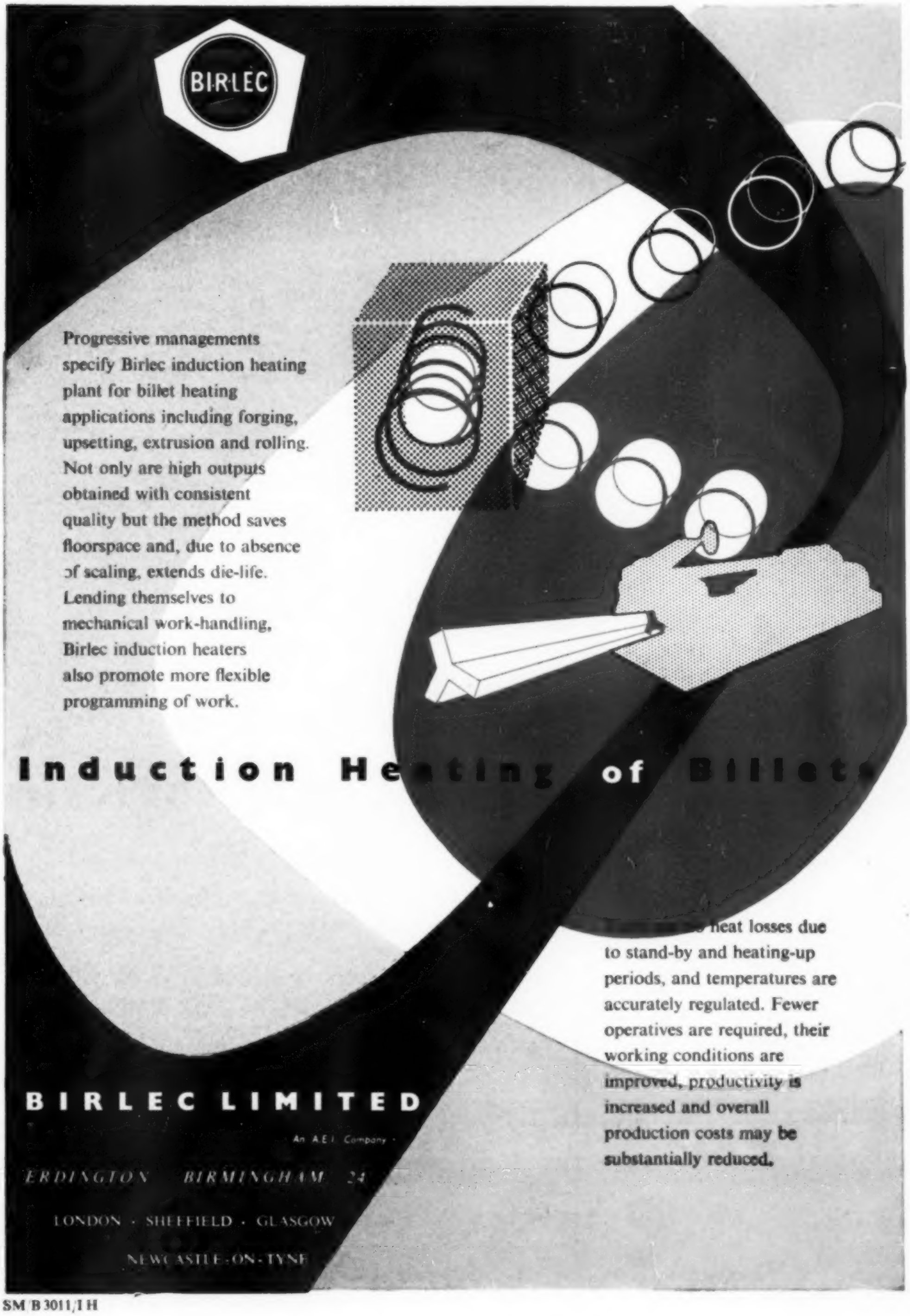
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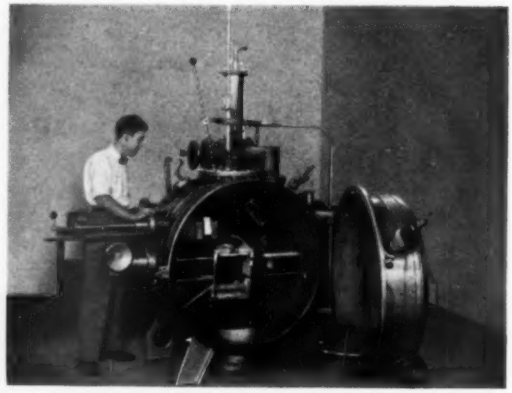

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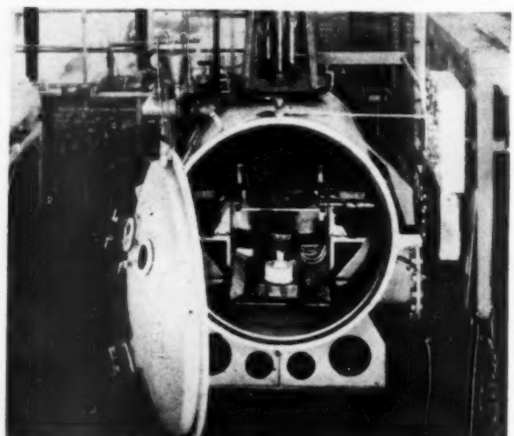

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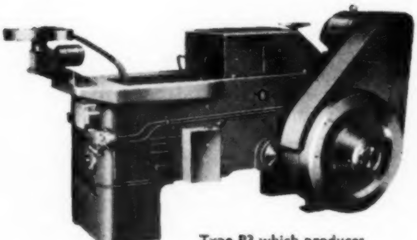

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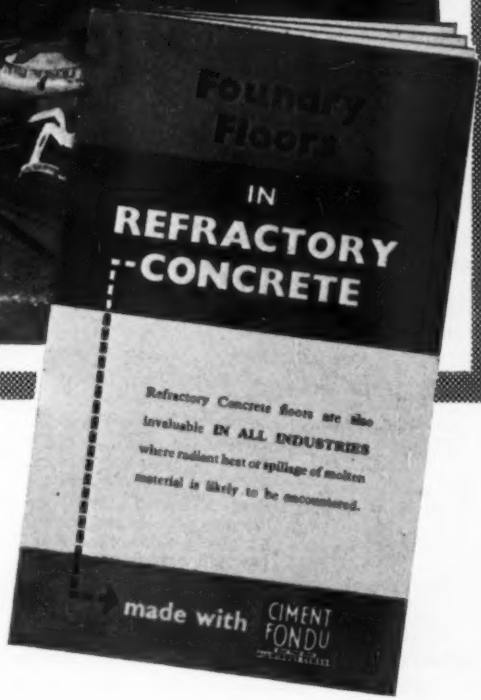

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CONTENTS

This Journal is devoted to metals—ferrous and non-ferrous—their manufacture, properties, heat treatment, manipulation, testing and protection, with research work and development in all these fields

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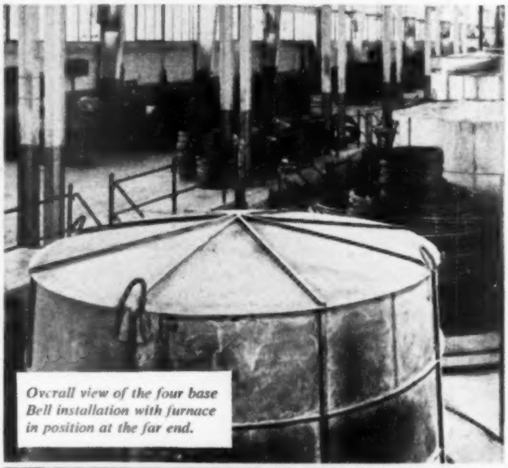

Overall view of the four base Bell installation with furnace in position at the far end.

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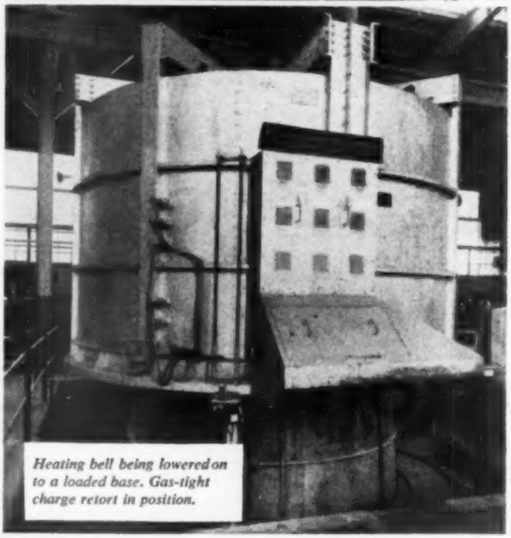

Heating bell being lowered on to a loaded base. Gas-tight charge retort in position.

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Foremen, Managers and Men

THE months roll past, and once more we have arrived at the time of year when the university undergraduate in his (or her) final year becomes a much sought-after person. Again we are glad to notice that the Cornmarket Press has undertaken the distribution of its annual 'Dictionary of Opportunities for Graduates' to help square pegs find their way into well-fitting square holes. With the news of the outstanding success of 'Zeta' it is perhaps tempting to think that a nation whose graduates are catered for so carefully, and whose scientists can achieve feats like this need have no particular worries about the future education and training of its technical personnel.

However, we know well enough that such is by no means the case; education and training are both of extreme importance and do continue to raise a number of acute problems. The number of papers and notes of speeches on this subject coming to this office is beginning to assume the proportions of a snowstorm, and the different opinions being aired to sound something like the Tower of Babel. There is the 'arts *v.* science' controversy and the possibility of a mixed arts-science course at Cambridge, the possibility of incorporating management studies in the engineering course at the same university and the suggestion of a centre of management studies at the University of Manchester, to mention but a few. Left, right and centre, questions are being asked regarding both the systems of training properly suited to the needs of a modern industrial manager and the kind of intellectual equipment that such a man should be expected to possess.

We are happy to publish this month a note on the recent opening of the new Staff Training College at Stoke d'Abernon belonging to Richard Thomas & Baldwins Ltd. It is clear that this leading steel company has given the question of foremanship and management training the most careful thought and is also very proud of the fact that one of the most beautiful of England's old manor houses has been obtained for use as a residential centre. Particularly noteworthy in this connection is the care and attention which has been lavished on its preservation and furnishing, not merely because it is scheduled as an Ancient Monument, but also with the understanding that contact with the richness and greatness of England's past, something all too often wholly missing from life in our grimmer industrial areas, is of itself a form of education. Such education is, perhaps, not altogether orientated towards making a man a good manager in the narrowest sense, but in the broadest sense it will do this and far more, for it will help him to become a 'whole' man.

The need for 'whole' men as future managers is of paramount importance, and there is always a lurking danger that the need may be forgotten or overlooked in the rush to establish suitable courses of instruction and to recruit the most promising material. Industrial management, when all is said and done, is not an end in itself, it is only a means to an end, the end being the maintenance of an economically sound industrial system, able to compete in world markets and ensure that in Great Britain there is sufficient material wealth to give all men an adequate opportunity to live their lives usefully and richly. But a less than whole man, however high his wages or short his working hours, will have the greatest difficulty in living a rich life, simply because doing so is an art in which he has never been instructed. A surprisingly large number of men, of course, do triumph over their environment in a most

The Re-nitriding of Steel

G. J. COX, A.I.M., A.C.T. (Birm.)

It has previously been usually accepted that a nitrided steel, unlike a carburized steel, cannot be restored to the full hardness after annealing. It is attempted to show in this article that this limitation, whilst true for aluminium-chromium-molybdenum steels, is not applicable to chromium-molybdenum or chromium-molybdenum-vanadium steels. The author, now of Mond Nickel Co. Ltd., Development and Research Laboratory, was previously with the Heat-treatment Department Laboratory of Joseph Lucas Ltd. The article will be continued in next month's issue

THE nitriding process offers unique properties to the engineering industries and, despite its costliness, it has undoubtedly a permanent position as a means of imparting a very high surface hardness to steel with the minimum of distortion.

The general features of the process are well known. However, this paper is concerned with one of the important differences between carburized and nitrided steel, namely the ease with which the former can be annealed for any purpose and then rehardened, whilst a nitrided steel cannot be so treated. In some respects this is a disadvantage with nitrided steel in that once a component has been hardened it cannot be altered, *i.e.* machining errors cannot be corrected, nor die sizes adjusted. A nitrided steel can be softened or annealed without much difficulty, but previously it has usually been accepted that it cannot then be re-nitrided or restored to the full hardness. It is intended to show here that this limitation, whilst true for the aluminium-chromium-molybdenum steels (En 41 type), is not applicable to the chromium-molybdenum (En 40A) or chromium-molybdenum-vanadium steels (En 40C).

Previously Published Work

A rather confused position exists with regard to the whole subject of re-nitriding steel and to clarify this a brief review of previous work is necessary. Before this is undertaken the use of the term re-nitriding needs comment. Wherever this term is used in the paper its meaning should be evident from the context. An explanatory summary of the various interpretations of re-nitriding will be found in the conclusions.

In very early work, Sergeson[1] suggested that re-nitriding was possible. He was led to make this suggestion after constructing the type of curve shown in Fig. 2 of the present paper.

Merten[2] described a de-nitriding treatment for steel and asserted that de-nitriding or softening followed by re-nitriding was quite practicable. He considered his process of particular value to the die-casting and forging industry in that with nitrided die moulds the shape and contour of the die can be adjusted after partial use. For de-nitriding he immersed samples of nitrided aluminium-chromium and aluminium-chromium-molybdenum steels in a 50/50 mixture of sodium and potassium chlorides at 820°C., after which they were slowly cooled. While no direct claim was made here that the full hardness could be obtained on an 'as-softened' surface when it was re-nitrided, neither was this supposition rejected.

Sergeson and Deal[3] stated that softening could be performed by annealing at 980°C., but that on re-nitriding the original surface it was not possible to obtain the full hardness. This conclusion was based not only on the work described in this paper but also on a re-appraisal of Sergeson's earlier experiments. Merten[4] questioned these results and insisted that re-nitriding was possible on a softened surface. However, he produced no experimental data to support this statement.

Later, Cunningham and Ashbury,[5] in a general description of their own nitriding practice, confirmed the results obtained by Sergeson and Deal. Further, they found that, by progressively removing layers of the original case and then re-nitriding, the hardness obtained after each re-treatment was gradually increased. They also showed that, when de-nitriding was carried out in salt, decarburization occurred, but it is of interest to note that, although unable to explain their results, they rejected the suggestion that failure to re-nitride could be ascribed to this cause.

Bullens[6] and Jenkins[7] both gave general accounts of the nitriding process. Bullens stated that

creditable manner, but a visit to any major centre of urban development practically anywhere will soon reveal the depressingly large majority of those who do not. Physical poverty may have disappeared, but spiritual poverty is unfortunately rampant.

It must not be thought that this form of spiritual poverty is necessarily confined to those of limited capacity who would never reach managerial status anyway. The American sociologist W. H. Whyte has put his finger very neatly on a source of serious weakness in a society dominated by large commercial and industrial corporations—the emergence of what he has called the 'organization man,' who, to quote another American investigator, D. Riesman, is wholly 'other-directed.' Successful management of a large corporate undertaking calls for a great deal of personal contact between individuals along the paths where their various interests and responsibilities overlap, and it is to everybody's benefit to ensure that these contacts are as easy and frictionless as possible. Too much emphasis on 'personal relations,' however, can lead to positions of responsibility always tending to go to the men who put easy personal relations before everything else, men whose attitudes, habits of thought and decisions will be dictated, not from inside themselves by ratiocination or conviction ('inner-direction') but by a consideration of themselves in relationship to the organization. These are the 'organization' men, very nice chaps and a pleasure to work with but not the stuff of which leaders are made, because without the organization they have nothing to fall back on.

Leaders of thought, men with ideas who are keen to try something new, whether or not the boss approves, are often prickly and difficult characters. The ideal management training should not seek to shave their spines but to help them to employ their talents wisely.

Redundancy

A FEW days ago, in the course of routine business, we visited a small town at the western end of South Wales. Here, something unknown for the best part of 20 years was to be seen again—small groups of unemployed men idle on the street corners, talking, smoking, kicking the curb stones, doing anything to help the idle hours to pass more quickly.

Mass unemployment is a national tragedy, and inevitably our feelings are coloured by memories of the late 'twenties and early 'thirties the moment the words 'out of work' are mentioned. It is necessary, therefore, not to let emotion blur our conclusions when considering the plight of these men in South Wales. They have not been made idle entirely owing to a recession in business activity; of equal if not greater moment is the fact that flat-rolled steel and tinplate production is becoming more efficiently organized. This was not the case 20 and 30 years ago, when not only business activity but technical development as well had reached a very low ebb indeed.

At the same time, in our desire not to be over-anxious, we must not be blind to signs and portents, particularly to those from the other side of the Atlantic. The unemployment figures and the level of steel production in the U.S. are serious reminders that all is not well, and some American economic experts are declaring that the remedial measures now being considered are already too late.

Remedial measures are possible in South Wales, mainly centred on the oil and iron-ore installations proposed for the development of Milford Haven. Let us hope that these will not be either too little or too late.

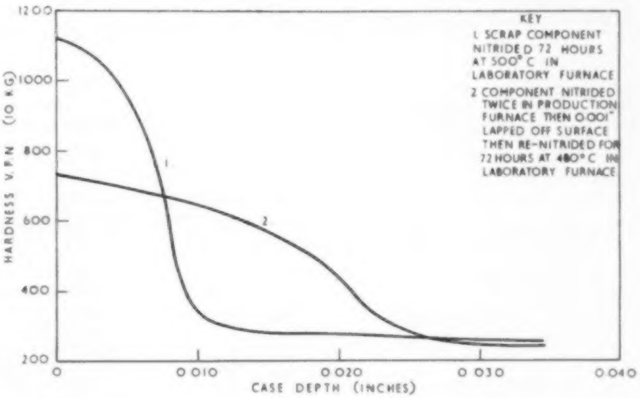


Fig. 1.—Depth-hardness curves for steel A

re-nitriding was not successful. Attention, therefore, was now concentrated on effective de-nitriding methods.

Consideration of these results and the nature of the available information gave the erroneous impression that for successful re-treatment the steel must be soft, *i.e.* have no residual stress at the surface. Although 800 V.P.N. is soft for this type of steel after nitriding, it is, of course, hard by any other standards. Thus Talbot discussed the re-nitriding of 'soft spots' and Merten considered 250 V.P.N. attainable by his de-nitriding method and therefore presumably a first requisite for successful re-treatment.

Various heat treatments, including that recommended by Merten, were tried in an attempt to soften the steel to its 'as-tempered' hardness or about 250 V.P.N. It was considered that 1,000°C. was the maximum temperature that could be used for these treatments. Above this temperature, surface deterioration and grain growth would obviously be likely, and it would probably be difficult to obtain a suitable furnace. Some of the samples were re-nitrided without further treatment, others were lapped after softening. These tests and the results obtained from them are summarised in Table II, from which it is seen that, although in many cases some increase in hardness had occurred on re-nitriding, the final hardness was very far from satisfactory.

Decarburization probably occurred in those samples which had been heated for prolonged times in cast-iron swarf (test 1). At the same time it appeared that only a prolonged treatment at a high temperature would lead to sufficient softening of the steel surface. Thus the hardness of the specimens treated in tests 2, 3 and 4 was too high, whilst decarburization again is possible in the specimen from test 5.

Therefore, a final test was made whereby bar samples were heated in a circulating argon (99·90% purity) atmosphere at 1,000°C. This was done by placing the test-pieces in a nickel-chromium box which was then sealed by welding, the box was then heated in an electric heat-treatment furnace. Now it was also becoming clear that the surface hardness of the specimen after de-nitriding was only of indirect importance. The more fundamental consideration was that of nitrogen leaving the steel. This point will be developed more fully in the next section, but from the purely practical point of view it seems logical that, if there is no nitrogen left in a steel and the analysis is correct, then on re-nitriding the full hardness should be obtained.

Thus, in this test, the specimens were heated as described for several times and, further, after each treatment, they were weighed, this being assumed to show the rate of nitrogen loss. It will be seen that this was never complete (Table III) and also, despite the severity of this treatment, the re-nitrided hardness was still low—although the best obtained so far. The actual surfaces of the specimens at the end of these treatments were quite clean, although some 'blueing' had occurred in some cases—probably as the charge

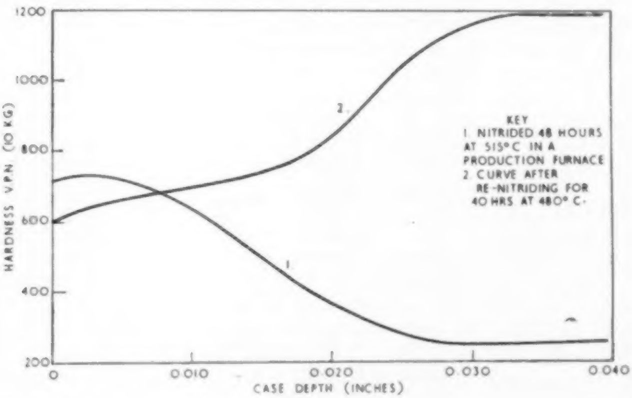


Fig. 2.—Effect of re-nitriding on the depth-hardness gradient of a component imperfectly nitrided in a production furnace

re-nitriding was not possible. Jenkins commented that for satisfactory re-nitriding it was necessary to remove completely by grinding all the original case. This was most probably based on the results discussed above and was not true re-nitriding as in this instance a completely new surface was exposed to the action of the gas.

Colegate[8] later repeated what appeared to be the consensus of opinion, *i.e.* that re-nitriding was not possible, and this led to some comments by Talbot[9] in the correspondence on this article. Talbot asserted that in their practice it was quite usual to re-nitride for the elimination of soft spots caused by surface contamination by such things as tin or sodium carbonate. He also claimed that shafts which after service had to be ground to a smaller diameter, thus removing part of the nitrided case, were also successfully re-nitrided. Talbot further stated that he found it possible to re-nitride no less than four times without embrittlement of the case or spalling. The first point made in his discussion is the one that the author was interested in. With regard to the other comments made by Talbot, it was clear from this survey of earlier work that if part of the case has been ground away the steel should respond to re-treatment. Re-nitriding of a properly hardened surface was considered a different problem.

To sum up, general opinion has it that de-nitriding followed by re-nitriding is not practicable. It was felt that this point needed checking in view of Merten's claim. Apart from this, Talbot had stated that imperfectly hardened surfaces could be re-treated satisfactorily. However, as a result of a production problem, some preliminary tests had already been made by the company the author was associated with and these had proved unsuccessful.

Equipment

The laboratory furnace referred to in this work was a cylindrical forced-air circulation tempering furnace. It had been adapted for nitriding by means of a nickel-chromium retort, chrome-ore sealed, and seated in the work chamber. As might be expected, the ammonia dissociations obtained in all the runs were fairly constant, varying between 15 and 18%.

Experimental Work: Part I

This investigation of re-nitriding was initiated by a production problem as noted above. Although the results obtained from the ensuing work are of general interest, the manner in which the initial problem presented itself will be described.

A large number of imperfectly nitrided fuel pump parts made in En 41 type steel had resulted from some production nitriding; whilst the furnace itself was receiving attention, the author was asked by the works metallurgist if he could suggest means to salvage the work already treated. It seemed that this might be done in one of two ways:—(i) To simply re-nitride the components. These had a hardness of the order of 800 V.P.N. Re-treatment in the production furnace had not altered this hardness, although the case was deepened. However, as this nitriding installation was in any case suspect, the first test was to re-nitride some of these components in a laboratory furnace.

(ii) If this did not succeed the alternative was to try the Merten de-nitriding technique and then again to re-nitride in a laboratory furnace.

The three types of steel used in the investigations will be described as steels A, B and C. The specified analyses of these steels are given in Table I, together with their approximate nitrided hardness. All the experimental work described in this first section was linked to the specific problem outlined above and was made with the aluminium-bearing steel A.

The first tests were designed to eliminate any possibility of a fault in the steel (apart from analytical failures), and to check the re-nitriding test already made in the production furnace. Un-nitrided scrap components and a number of the faulty components (V.P.N. 800) were simply nitrided for 72 hours. The results can be seen in the depth hardness curves (Fig. 1). It will be seen (*a*) that the steel itself was satisfactory, and (*b*) that direct

TABLE I.—*Analysis and designation of steels used*

Steel	Type	Composition, %								Approximate nitrided surface hardness, V.P.N.
		C	Si	Mn	Ni	Cr	Al	Mo	V	
A	1½% chromium-aluminium-molybdenum (En 41)	0·40	0·35	0·65	—	1·60	1·00	0·20	—	1050—1100
B	3% chromium-molybdenum (En 40AB)	0·30	0·30	0·45	0·50	3·00	—	0·40	—	800— 850
C	3% chromium-molybdenum-vanadium (En 40C)	0·40	0·35	0·60	—	3·00	—	1·00	0·20	850— 900

TABLE II.—*De-nitriding experiments with steel A*

Test No.	Description of sample (or prior treatment)	Surface hardness V.P.N.		De-nitriding treatment	Surface hardness after de-nitriding V.P.N.		Surface hardness after re-nitriding V.P.N.	
		2½ kg.	10 kg.		2½ kg.	10 kg.	2½ kg.	10 kg.
1	Imperfectly nitrided components. Nitrided in a production furnace for 48 h. at 515°C.	820	730	Heated for 16 h. at 950°C. in cast iron swarf. Pot then cooled outside furnace. Sample halved then: (*a*) one section shot-blasted	166	207	320	390
				(*b*) one section left 'as softened'			443	420
2	Samples as test 1 above	824	736	(1) Heated for 1 h. at 800°C. in *neutral salt, then air-cooled	445	448	540	503
				(2) Heated for 15 min. at 900°C. in neutral salt, oil quenched then tempered for 2 h. at 550°C.	566	544	560	592
				(3) As 2 but austenitized for 1 h. at 900°C.	493	508	574	602
				(4) Heated for 1 h. at 950°C. in neutral salt	349	349	520	508
3	Untreated scrap components. Nitrided for 48 h. at 515°C. in a laboratory nitriding furnace	1168	1070	(1) As 1 above	483	508	673	645
				(2) As 2 above	536	592	710	673
				(3) As 3 above	493	478	641	627
				(4) As 4 above	333	348	490	536
4	Turned bar stock in the hardened and tempered condition. Nitrided for 72 h. at 500°C. in laboratory furnace	1170	1064	Heated for 3 h. in neutral salt and then removed and cooled in sand. Each bar was lightly polished prior to re-nitriding	403	417	(1) 560	508
							(2) 550	536
							(3) 585	536
5	Samples as test 4 above	—	—	Heated for 6 h. at 950°C. in neutral salt. Air-cooled	279	281	(1) 550	550
							(2) 434	560
6	Turned bar stock in hardened and tempered condition:			Heated for a total time of 17 h. at 1,000°C. in an argon atmosphere, then:				
	(1) Nitrided 24 h. at 500°C	—	—	The surface of these bars was lightly polished prior to re-nitriding	—	338	706	673
	(2) ,,	—	—		—	314	706	707
	(3) ,,	—	—		—	314	680	707
	(4) ,,	—	—		—	299	689	724
	(7) ,,	—	—	These bars were hardened from 900°C. and tempered for 2 h. at 550°C. Then polished as above	—	298	743	743
	(8) ,,	—	—		—	296	689	698
	(9) ,,	—	—		—	320	673	690
	(10) ,,	—	—		—	285	673	715
	(11) Not nitrided	—	—	No treatment applied	—	—	1064	1056

* The neutral salt used in these and subsequent tests was a 50 : 50 mixture of sodium and potassium chlorides

TABLE III.—*Weight tests on steel A (made on bars used in test* 6) (*weights in grammes*)

Bar No.	Weight before nitriding	Weight after nitriding for 24 h. at 500°C.	Weight after heating for 5 h. at 1,000°C. in argon gas	Amount of original weight gain remaining (%)	Weight after further 5 h. at 1,000°C. in argon gas	Amount of original weight gain remaining (%)	Weight after further 5 h. at 1,000°C. in argon gas	Amount of original weight gain remaining (%)	Weight after further 2 h. at 1,000°C. in argon gas	Amount of original weight gain remaining (%)
1	71·3774	71·4740	71·4253	49·6	71·4237	47·9	71·4140	37·9	71·4126	36·4
2	71·1333	71·2323	71·1786	46·8	71·1598	26·8	71·1478	14·6	71·1474	14·2
3	72·1242	72·2249	72·1709	46·4	72·1657	41·2	72·1512	26·8	72·1415	17·2
4	71·5967	71·6982	71·6409	43·5	71·6399	42·6	71·6383	41·0	71·6376	40·3
5	70·7397	70·8392	70·7842	44·7	70·7820	42·5	70·7772	37·6	70·7768	37·2

cooled down. As the surfaces were cleaned before re-nitriding this was not felt to have any effect on the final result.

To elucidate the effects, if any, of prior hardness on the re-nitrided hardness, a partly hardened sample was taper-ground and a depth hardness plot made. It was then re-nitrided and the hardness level along the taper was again determined. From the resulting curves (Fig. 2), it is seen that a marked difference exists between these results and those obtained from the de-nitrided specimens. Thus, here at a hardness of 300 V.P.N. on the original curve the corresponding hardness after re-treatment is about 1,000 to 1,100 V.P.N. On the other hand, although many of the de-nitrided specimens were softened to 300 V.P.N. on re-nitriding, the best results obtained were about 700 V.P.N. These curves show that the re-nitrided hardness is basically related to the alloy content of the steel matrix and that hardness itself has only an incidental effect.

Summarizing these results it can be said that in the case of Merten's claim the results obtained had confirmed the conclusions of other investigators. With regard to Talbot's remarks, the curves of Fig. 2 show that the 'soft spots' he describes could only be surfaces which had not been nitrided at all during the first treatment—otherwise a satisfactory re-treatment could not have been obtained.

Discussion

Although this is essentially a practical paper, an attempted explanation of the results in the light of present knowledge of nitriding theory will be made.

Currently, it is accepted that the hardening effect in nitriding is due to combination between nascent nitrogen and the alloying elements in the steel, to form a sub-microscopic precipitate of alloy nitrides. The formation of these fine particles is supposed to lead to lattice distortion and slip interference and consequently a general hardening effect. Elements which form the most stable nitrides are therefore added to the steel—usually aluminium or chromium. Once the elements are combined with the nitrogen, or precipitated, they are removed from any further reactions. Thus the hardening effect is dependent upon the alloy content of the matrix. On this basis, therefore, it would seem that it is only to be expected that direct re-nitriding would be mainly unsuccessful since, after one treatment, practically all the alloy elements in the surface layers of the steel would have been precipitated.

It is now necessary to examine this hypothesis more closely and relate it to the cause of the initial unsatisfactory nitriding treatment. A low hardness after nitriding can be due to two general causes:—

(*a*) Too high a nitriding temperature. Here the application of the hypothesis is straightforward, as all the alloying elements in the surface layers will have been used ineffectively.

(*b*) Insufficient gas supply or poor gas circulation. If the initial low hardness is ascribable to this cause it can be objected that, since only part of the nitride-forming elements have been used, a proportionate amount must remain in solution. They can then be used in a direct re-nitriding and therefore should account for the remainder of the required hardness. However, the hardening effect is not necessarily additive, although it would be expected that some hardness increment would occur. A series of experiments made to check this point were invalidated by a subsequent discovery of a fault in the test and this aspect needs further investigation.

If these explanations are correct then the first requisite for a successful de-nitriding treatment is that it must eliminate all the nitrogen from the steel so that the nitride-forming elements are all available for the next treatment. The weight tests carried out after prolonged heating in an argon atmosphere (Table III) show that some 20 to 40% of the original weight gain, or nitrogen, remained. It would seem that very severe and impracticable treatments would be necessary to completely eliminate the nitrogen from these steels.

However, it has already been pointed out that the highest hardness obtained from any of the re-nitrided aluminium-bearing steels was that resulting from the heating tests in argon and it can be seen that this hardness is of the order of 700 V.P.N. (Table II). These samples were considered to be as fully de-nitrided as is practicable and it was felt significant that the hardness obtained is similar to that one would expect to obtain from a nitrided steel alloyed with only 1% or so of chromium. A possible explanation of these results, therefore, was that the chromium in the steel was being used again effectively during the re-nitriding treatment whilst, on the other hand, the aluminium was making no contribution to the re-nitrided hardness and might well be supposed to be too stable a compound to break down. (It will be remembered, of course, that the En 41 type steel contains 1·0% aluminium and probably has about 1·5% chromium present in the ferrite.)

The chemical decomposition temperatures of aluminium nitride and chromium nitride show the former to be far more stable and, although the application of such data here is of doubtful value, it was thought to be an indication of what could happen; the order of stability of these nitrides can be reasonably assumed to remain the same.

An objection that can be raised to this reasoning is that in all the de-nitriding tests the case hardness has fallen and yet it is postulated that aluminium

(*Continued on page* 68)

LETTERS *to the Editor*

'Trickery'

SIR: The leading article under the above title in your issue of January, 1958, is perhaps a more excellent thesis on the subject than the author intended; misquotings of facts and statements and misinterpretations of the laws of science, all provide a good basis for trickery in the dictionary sense. However, it is important to get straight the relation between theory and practice.

The laws of thermodynamics, which are the basis of the laws of physical chemistry referred to in this article, tell us that a rifle bullet fired vertically in a gravitational field cannot go higher than a height precisely determined by the energy it started with. One could play a 'trick' on the bullet by attaching a small drag to it and it wouldn't go so high. Is this 'cheating' the laws of science? Only to those who misinterpret the laws to make them say that the bullet *must* go to the prescribed height. All of the examples in your article involve this misinterpretation.

The theoretical approach to a problem often includes generalizations of less rigorous validity than the above and it is in connection with these that practice can sometimes, through 'tricks of the trade,' do better than theory. Usually, of course, practice falls far behind theory and therefore it is right that one should remember that sometimes the reverse can occur. The article has done a good service in repeating this point, but it is a pity that its author cannot find examples that do not depend on a misreading of French and on a misquoting of facts.

CHARLES GOODEVE

British Iron & Steel Research Association,
11 Park Lane, London W.1

January 29, 1958

[We agree that the word 'trick' is capable of different meanings, but the meaning we intended to convey in our leading article was precisely that given to it by Sir Charles in his speech at Broken Hill (referred to in our first paragraph) when he spoke of 'tricks' steelmakers have learned in order to make chemical reactions go one way when they would be expected, according to chemists, to go the opposite way.

With regard to our alleged misreading of French and misquotation of facts, the passage in question, which concludes a paper on the physical chemistry of steelmaking presented by Sir Charles Goodeve and Dr. J. Pearson to the Société Française de Métallurgie in 1950, is as follows:—

> 'Comme il ne semble pas qu'il y ait de moyen pratique permettant d'éliminer le phosphore si ce n'est par oxidation, ni d'élever le potentiel d'oxygène régnant dans un haut fourneau, nous *sommes obligés de considérer d'un oeil sceptique la suggestion d'une élimination du phosphore avant le traitment du métal dans le four Martin ou le convertisseur* (our italics). On pourrait peut-être faciliter l'opération en réduisant la température a celle de la zone de fonctionnement du cubilot. Le découverte d'un constituant de laitier qui présenterait une plus grande affinité pour P_2O_5 que n'en présente la chaux permettrait de réduir l'activité de P_2O_5, mais la masse de connaissances que l'on a accumulée sur les composés du phosphore ne laisse pas prévoir pour cette découverte un avenir rapproché.'

Now in point of fact pre-refining processes for the removal of phosphorus from steel have been perfected (*e.g.* the 'Rotor' process in Germany) without either reducing the temperature of the reaction to the level of that in a cupola or waiting for some new slag-forming compound of phosphorus to be discovered—because German engineers refused to be browbeaten by physical chemists and determined to see what 'tricks' they could do.

In the same way, a few years ago, 'a sceptical eye' would no doubt have been cast on the proposal to smelt zinc in a blast furnace. Fortunately, however, the team at Avonmouth do not seem to have allowed this hopelessly negative attitude to have deterred them.

That this attitude is still very much alive, however, is regrettably obvious. The I.M.M. could not turn a sceptical eye on something already in existence, instead they chose to turn a blind one.—EDITOR]

BOOKS

Directory of Opportunities for Graduates, 1958

Edited by Clive Labovitch. Cornmarket Press Ltd. 1958. 8*s*. 6*d*. *nett* (9*s*. 4*d*. post free). Free distribution to all final-year students at universities in the UK.

'THE more successful this country becomes in balancing the output from the universities with the opportunities which exist, the more carefully we shall conserve that most precious product of our universities—the trained mind,' writes Lord Weeks in a preface to the 1958 edition of the 'Directory of Opportunities for Graduates.'

More than 220 organizations recruiting graduates are included in this directory, which is very much larger and more comprehensive than the 1957 edition: 20,000 undergraduates in their final year at all the universities of Great Britain will receive a copy of the book within the next few days. The purpose of the directory is to provide final-year students with a clear and comprehensive picture of the openings available to them, particularly in industry where so many opportunities now exist, by presenting information in a standard form. Each entry in the reference section gives details about the company, its products or activities, the types of graduates required, the work involved, the training and salaries offered, and the location of employment. A classified index lists firms under headings describing their activities with tabulated information about the firms.

The directory contains a 40-page editorial section which was compiled with the assistance of an editorial advisory board consisting of C. E. Escritt, M.A., Secretary of the Oxford University Appointments Committee, E. D. Foster, Editor of 'The Director,' and R. W. Pennock, M.A., of the Central Staff Department of Imperial Chemical Industries Ltd.

Structural Chemistry and Metallurgy of Copper

Fifth Gillett Memorial Lecture, presented by D. K. Crampton at the 1956 annual general meeting of the American Society for Testing Materials. Published by the Society, 1916 Race Street, Philadelphia 3, Pa., U.S.A. Pp. 28. \$1.50 (11*s*. approx.).

DR. CRAMPTON discusses some of the new work on recrystallization and grain growth of copper alloys, investigating time intervals much shorter than previously used. He also discusses the structural chemistry of copper and copper alloys, particularly in relaxation of grains and grain boundaries both in pure copper and in some copper alloys; new investigations of the fundamentals of corrosion and corrosion resistance of copper, and some of the factors affecting incidence of corrosion pits.

A New Refractory Material

An Example of Scientific Research

PROF. LOUIS LONGCHAMBON

The author insists on the idea that progress in the field of refractories is not likely to come from the refractory-materials industry itself but that the initiative must be taken by the consuming industries. He describes the developments made quite recently in refractory cements, which were discovered more than one hundred years ago by Sainte-Claire Deville, a discovery which shows the possibilities of scientific research in a field which is generally left to empirical methods. This article, the first part of which is published this month, is a slightly abridged version of a paper read at 'Journée des Réfractaires' held in Liège last year, and published in French in the 'Revue Universelle des Mines,' October, 1957. The author is professor at the Faculté des Sciences de Nancy, and director of the Laboratoire des Réfractaires, France

IN a number of industrial fields our present age is characterized by an extremely rapid evolution of techniques and by the creation of synthetic bodies which replace traditional raw materials, or open up new possibilities. This state of affairs is due to the immense amount of scientific and technical research which is developing throughout the world, creating a new climate in which no industrial leader can fail to be interested. One of the largest American makers of synthetic products recently asserted that, in ten years' time, half their production would consist of chemical compounds now unknown. What will be these new bodies ? How will they affect the present industrial equilibrium ? What impact will they have on our own existence ? So many questions for which it is impossible to find the answers.

But in face of this extraordinary revival we must point out that the refractory business stands out by its relative stagnation. The raw materials we use have not changed in composition or shape since the beginning of the industrial age and the most modern of them were already in existence in the last century. For instance, open-hearth furnaces have always worked at 1,750°C., a limiting temperature imposed by the silica roof, and no new raw material has made it possible to make the slightest improvement in temperature of working.

The refractory industry has, however, improved these materials, under pressure of competition. Refractory clays, silica, magnesia, are now all treated with a technique which has been progressively standardized. The corresponding raw materials have thus reached a certain stage of perfection in accordance with standards which ensure regularity, but at the same time fix a limit to their progress. No improvement can be expected from refractory clay bricks, or silica or magnesia, for each of these products has reached the technical ceiling imposed by the qualities of the natural product from which they are made.

Such a situation can give satisfaction to the makers of refractories and to maintenance engineers in the works. Thanks to standards and specifications they do indeed speak the same language and can reach agreement on the performance demanded, but, in respect of technical progress, such a situation is called stagnation. It is indeed essential for progress in an industry, which uses high temperatures in its manufacturing or treatment processes, that the refractory chambers should allow of higher and higher temperatures being obtained without it being possible to fix a limit to these higher temperatures, and this with continually falling cost prices. It can be seen to what extent such a programme is opposed to the present actual situation.

Should the refractory materials field then be so unique that no improvement, no new method, is any longer possible ? I propose to show that, there as elsewhere, systematic research is fruitful. But first of all I should like to try and justify the indifference which manufacturing engineers have shown towards refractories, an indifference which is responsible for the state of affairs I now deplore.

There are in industry unrewarding sections which

How such a technique, so perfectly described and of which the interest had been made so very clear could remain undeveloped for a hundred years is a subject of amazement.

Work of the Société des Ciments Lafarge

It was in a roundabout way that French science was put back on the right track and it is to the engineers of the Société des Ciments Lafarge and Le Teil that we owe the rediscovery of the hydraulic and refractory aluminous cement of Sainte-Claire Deville, in those laboratories made famous by H. Lechatellier and E. Rengade, in which was conducted one of the finest pieces of combined research on cements.

In 1908 J. Bied sought to determine the constituents of a cement which stood up to attack by sulphates. He had the idea of increasing up to the maximum the ratio Al_2O_3/SiO_2 and made direct use of bauxite and limestone as raw materials by making a clean fusion of these constituents.

The percentage composition of this cement is approximately:—Al_2O_3, 40; CaO, 40; SiO_2, 10; Fe_2O_3, 10.

Cast cement is therefore, broadly speaking, a monocalcic aluminate with some excess of limestone and siliceous and ferrous impurities. It was thus the first industrial production of Sainte-Claire Deville's cement, apart from the impurities in the bauxite. The hydraulic properties of this cement, especially its speed of hardening, and its high resistance to sulphates, were quickly spread in the field of mortars and concretes. But it fell to Kestner, the founder of the Société de Chimie Industrielle, to recognize the relationship of the aluminous cement with that of Sainte-Claire Deville and to recommend it as a binder for the manufacture of refractory blocks.

Kestner put on the market a mixture, ready for immediate use, of baked refractory earth (chamotte) and aluminous cement, but this mixture had only a restricted sale in the refractory market because its suitability for solving the many problems, which that industry presents, was not established and, indeed, it could not solve them all.

It was in 1937 that the Société des Ciments Lafarge decided to study the possibilities of using aluminous cement as a refractory and asked for the author's collaboration. The Société Secar was soon formed and specially entrusted with these investigations under the direction of L. Jequier and then of P. M. Sauzier with the collaboration of P. Lhopitalier, director of the laboratories of the Etablissements Lafarge.

From 1937, I established the technical characteristics of refractory concretes based on cast cement, mixed with burnt earth, corundum, silicon, magnesia, and showed that it was possible to produce basic, neuter or acid revetments, suitable as substitutes for the corresponding traditional materials.

In the technical field the problem was to define the method of construction best suited to the new material and I proceeded to build a Siemens-type reheater, cast in a single block weighing 13 tons. The firing of such a monolith and its performance, in spite of variations in temperature specially applied for this demonstration, established in a spectacular and definitive way the possibilities which could henceforward be obtained with such a material. Then began the study which has been going on for 20 years and is still not yet finished nor near to being. This is concerned with deciding, for each kind of application, what is the best concrete and the best technical method of applying it as a substitute for the traditional materials and methods of construction. Later on I shall give many examples of these substitutions.

But the use of cast cement over the whole range of temperatures is limited by the impurities in the bauxite, and so it required the use of pure alumina to get the high temperatures of working fixed by Sainte-Claire Deville. In 1950 the Research Department of the Lafarge Co. decided to sinter very pure raw materials, specially selected limestone and alumina obtained from bauxite by chemical methods. The refractory cement of Sainte-Claire Deville, developed in the form of a hydraulic binder, is now offered with the following chemical composition:—alumina, 75%; calcium, 25%, with less than 1% impurities.

As cast cement, of which it is the final form, pure calcium aluminate is a cement with a slow setting and a quick hardening, and it has the property of retaining great cohesion during dehydration, as Sainte-Claire Deville quite well observed. In this way, good concretes, which attain and easily exceed a strength of 500 kg./sq.cm. (7,100 lb./sq.in.), easily retain a strength after baking at 1,300°C., which can still reach 250 kg./sq.cm. (3,550 lb.). This property seems to be due to the fact that hydrated aluminate loses its constituent water without great change in the Al_2O_3 network. This relative indifference to dehydration is such that a large mass of concrete can be put into contact with fire on one of its faces only without the bulk of the material suffering.

The true melting-point of calcium aluminate is about 1,650°C., but softening is appreciable from 1,300°C. When used in sintered aluminous concrete, following the technique of Sainte-Claire Deville the refractoriness of the mixture increases in agreement with the Al_2O_3CaO diagram, that is to say in line with the enrichment in alumina. The real melting point of a concrete with corundum to 300 kg. of cement per cubic metre reaches

technicians neglect and willingly leave to the empiricism of the users. It is in this way that the engineer has little hold on refractory materials, of which the complex nature and behaviour baffle even the most obstinate. All the more is this so because manufacture of the finished refractory product is generally done at a distance from where it is used, so that the troubles of the manufacturer do not immediately coincide with those of the user. In any case, the manufacturing engineer considers refractory material as a complete product for which the maker is responsible to him. He does not see in this material a useful collaborator in his productions. He quite reasonably complains of thermal or chemical defects and does not feel himself to be personally involved in this matter. From indifference to indifference he ends up by leaving this worry and responsibility to his purchasing department. The latter department then refers to standard specifications and is not able to give to the makers any technical requirement with a constructive value.

Sainte-Claire Deville Refractory Cement

Mineralogists have always been tempted to explain the genesis of natural ores and they have thus been led into making a synthesis of numerous mineral classes, either by purely igneous methods or by introducing pressure and steam into these methods. These syntheses, which were of purely speculative interest at first, have become, as a result of industrial methods of manufacture, raw materials of a high degree of purity, which have progressively taken the place of the natural raw materials. It is in this way that, in this study, closely confined to the study of refractory concretes, we find ourselves confronted with two synthetic products, corundum and calcium-aluminate, created in 1848 by the mineralogist, Ebelmen.

Ebelmen sought to reproduce natural mineral species and to create new species by igneous methods. For this he put metallic oxides into a mineralizator bath, as it was then called, in fact into boric acid and sodium borate, the whole being then submitted to the highest temperatures obtainable with furnaces with Sèvres porcelain hearths. In this way he made synthetic corundum and many crystalline spinels, particularly cubic calcium aluminate. But it is to Sainte-Claire Deville that we owe our knowledge of both the hydraulic and refractory properties of calcium aluminate as well as the creation of that extraordinary concrete which is obtained by mixing corundum and calcium aluminate.

It was in 1856 that Henri Sainte-Claire Deville published in the *Annales de Physique et de Chemie* two memoirs, one dealing with the obtaining of very high temperatures, and the other with the manufacture of sodium and of aluminium. Was it the importance of the second which caused the first to pass unnoticed ? Or was it the lack of interest which the heating industry has always shown towards refractory materials, only secondary agents in their work ? It still remains that the eminent savant had just given laboratories and industry an exceptional material, the value of which was not appreciated by anybody to such a degree that a century had to elapse before this discovery ceased to be forgotten and took on an industrial reality.

On reading these hundred-year-old pages we no longer know how to place the author in the nomenclature of today. He was in turn technical assistant, research engineer, works manager, Professor at the Ecole Normale Supérieure. Sainte-Claire Deville is indeed the complete man of science, setting himself a problem and following it through in all its details by himself.

Some people will probably think that science was easier to do in its early stages, when everything was still to be discovered and learnt, whereas nowadays a whole hierarchical staff would be required, ranging from laboratory assistants to directors of research, helped by specialized mechanicians, librarians and secretarial translators.

But the problem set and solved by Sainte-Claire Deville was not a simple one and its difficulty has not diminished even in the present days. It consisted of obtaining and using very high temperatures, actually 1,800°C. It was necessary to create the whole technique of combustion, furnaces, suitable refractories, and this problem has no other solution today than the one which Sainte-Claire Deville provided, working alone in his laboratory.

But here is the description given by the author himself:—

> 'I use also as cement a good mixture of equal parts of alumina and crushed marble. These are heated to the highest temperature which can be got with a good blown furnace. Sometimes the union of the alumina and lime is not perfect, but the material so obtained can still be used even though this has not been sufficiently fired. The calcium aluminate has not melted, but the materials are combined in such a way as to absorb water and form a kind of cement. By mixing this with twice its weight of well-cooked alumina, we can produce rough pots which quickly become very hard in air and which can sustain drying, working and heat of firing without splitting.
>
> 'In whichever way they are made, these crucibles, once they are baked, withstand all tests, such as heat, sudden cooling, nearly all raw materials which can be made to react, even sodium, and consequently all metals, none of which can harm them. Alumina crucibles have a great advantage over clay crucibles. Alkaline metals do not reduce them in the way they reduce any siliceous matter. Ordinary metals take up a little silicon from clay by simple contact, but this is not so with alumina crucibles. In those cases where a lime crucible cannot be used, an alumina crucible can nearly always be used.'

This description is so condensed that it clearly contains all that I am going to explain and much more besides, which would take years to work out.

Series on Heat Treatment

Oils for the Quenching of Steel

H. E. PRISTON, Ph.D., B.Sc., F.R.I.C.

The author, of Shell-Mex and B.P. Ltd., compares the properties of various quenching fluids for steel-hardening operations. The evaluation and handling of quenching oils and the testing of heat-treatment oils are among the subjects discussed. This is the third of the lectures on 'Modern Trends in the Heat Treatment of Steel,' given at the Wolverhampton and Staffordshire College of Technology

THE term 'heat treatment' can apply to any thermal process intended to modify the mechanical properties of a metal, *e.g.* hardness, ductility, etc. In this field mineral oils find their main application as quenching fluids in the hardening of steels. They are also used to some extent in tempering operations. Light alloys and some other special alloys sometimes undergo similar treatments, but the use of oils in the heat treatment of non-ferrous metals is of very minor importance.

HARDENING OF STEELS

Metallurgical Considerations

Before discussing the functions of quenching fluids, it is desirable to know something about the changes which take place in steels when they are heated and cooled. Steels fall into two main categories, plain carbon steels and alloy steels. The former are virtually alloys of iron and carbon, although they may contain small quantities of other elements, such as sulphur and phosphorus, which are present as impurities. Alloy steels contain additional elements, *e.g.* nickel, chromium, tungsten, etc., which are present for the specific purpose of imparting special characteristics to the steel.

If heat is applied to a steel specimen and the rate of increase in temperature of the specimen is recorded, certain pauses can be observed where heat is being absorbed by the specimen, but there is no corresponding temperature change. These pauses, known as critical or transformation points, are caused by internal changes in the steel which require the absorption of heat to bring them about. Similar critical points can be observed in the cooling curve of a steel specimen which correspond to liberation of heat when converse changes take place in the steel. Some of these critical points are of importance in the hardening of steels and they occur in general within the temperature range 700 to 1,100°C. The critical points in the case of plain carbon steels usually occur within a fairly narrow temperature range, 730 to 900°C.

As a help towards a complete understanding of this, we must consider the state of the carbon present in the steel. At temperatures above the critical range the carbon is in solution in the iron and this solid solution is known as austenite. At temperatures below the critical range, the carbon is present as iron carbide and is not in solution. It is possible, however, to obtain a super-saturated solution of carbon in iron by cooling the steel rapidly through the critical temperature range. By cooling rapidly the carbon remains in solution to a much lower temperature and, as the steel structure is more rigid at the lower temperature, only a partial change to the original state of the cold steel can take place. This solution, known as martensite, is the characteristic constituent of fully-hardened steel. Like austenite, martensite may have various carbon contents and, therefore, since carbon controls hardness, various hardnesses. There is a critical cooling rate for every steel, below which the steel is only partially hardened and above which full hardness is obtained. As a general rule, alloy steels have lower critical cooling rates than plain carbon steels and, therefore, they do not require to be cooled so rapidly in order to obtain full hardness.

The Quenching Process

In order to understand the reason for selecting any particular quenching fluid for a hardening operation, it is necessary to examine typical cooling curves of the type shown in Fig. 1, which represents the change in temperature of a steel specimen being quenched from a high temperature in a liquid. This curve shows three fairly distinct stages marked A, B and C. During the first, or

1,860°C. and softening of such a concrete is not appreciable before 1,700°C.

It will be seen that all these results confirm in every detail the results of Sainte-Claire Deville. They also show that the new industrial product reaches the quality of the laboratory product. Such a result, even if it is the work of cement specialists, could only be developed industrially with the help of progress made in the aluminium industry, which has enabled aluminium to be obtained at a sufficiently low price. It is also thanks to improvements made in quite an independent way by technicians in the abrasive industry, who now produce extremely pure corundum on an industrial scale.

And so it is only in the last few years that the combination of this new cement with synthetic corundum has redeveloped, on an industrial basis, the hydraulic setting refractory mixture of which Sainte-Claire Deville had understood the full importance from 1856. This concrete, which allows of building *in situ*, without any prior baking, of monolithic refractory blocks resisting up to 1,800°C., is quite the most important contribution which science has made to the heating industry in the refractory field.

The introduction of concrete into the art of building houses and public works has transformed traditional practices. The saving of time, space, weight and the ten-fold increase in loads and spans have changed the method of even conceiving edifices both technically and aesthetically. And now this revolution is winning over the heating industry by taking over the manufacture of hot-gas pipes, furnaces of all kinds, brick kilns, lime and cement burners, etc. It is penetrating into metallurgy with annealing furnaces, melting furnaces for zinc and aluminium, and its ambition is boundless since the potentialities of this new material surpass incontestably those of the traditional materials. Actually refractory concrete has only succeeded in making a serious inroad into the construction of furnaces of all kinds since it was put forward to users no longer as a new recipe or a commercial speciality, but as a new technique, perfectly defined within its limitations as in its possibilities, a technique without any mystic, accessible to all those who are prepared to assimilate its elementary data.

The properties of cast cement, or Lafarge Fondu, and of pure calcium aluminate, known commercially under the description ' Secar 250,' as well as of all the concretes which can be made from them, have been determined with the required precision. The engineer can use them, therefore, with full security in every case where it is a question of pure resistance to heat, for refractoriness follows in practice simple rules and laboratory tests are easily adaptable to production. It is otherwise with chemical resistance to magmas, of which the attack as a function of temperature must be studied in each particular case. But in this field also, our knowledge of the behaviour of concretes has been greatly enriched by the many industrial experiments carried out with methodical prudence.

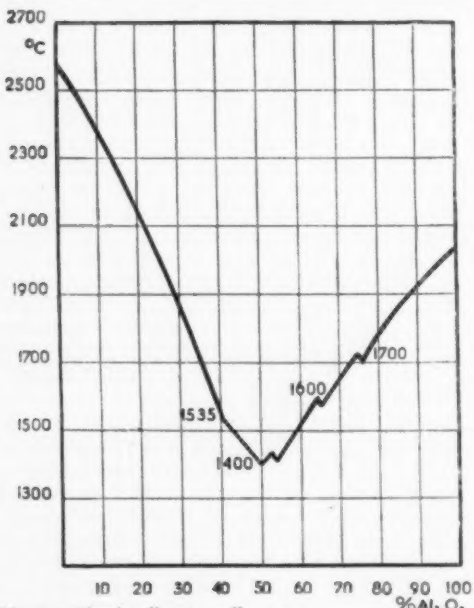


Fig. 1.—Alumina-limestone diagram

Characteristics of Refractory Concretes

We can place Secar 250 on the alumina-limestone diagram, Fig. 1, at the point corresponding to its alumina content, 75%, which shows a melting point of about 1,700°C. This combination shows a liquidus phase from 1,590°C., but in practice the industrial product shows signs of softening from 1,300°C. to melt fully at 1,650°C. This difference between the industrial and the theoretical product arises on the one hand from the fact that combination between limestone and alumina is not total and, on the other hand, from the presence of a small amount of impurities. The trend of the diagram shows that every enrichment of alumina will lift the melting point quickly, whilst maintaining a liquid phase starting from 1,700°C. On the contrary, every enrichment in limestone will lower the melting point down to the region of 1,400°C.

Corundum is then the optimum aggregate of calcium aluminate. In practice, we shall see that corundum concretes allow of the construction of furnace walls and refractory objects which hold good up to 1,800°C.

(*To be continued*)

usually a marked increase in the viscosity of fatty oils, due to the formation of gummy oxidation products, and, as a result, the quenching efficiency falls off. Thickening also increases losses by greater carry-over of oil on the parts being quenched and makes the oil more difficult to remove from the work-pieces. Another disadvantage of fatty oils is that they tend to form soaps with salts from salt baths which may be used to heat the parts being treated. These soaps not only contaminate the oil, reducing its life, but they interfere with cooling rates as they are formed on the surface of the parts being quenched. A minor trouble with fatty oils is that they are inclined to develop unpleasant odours in service.

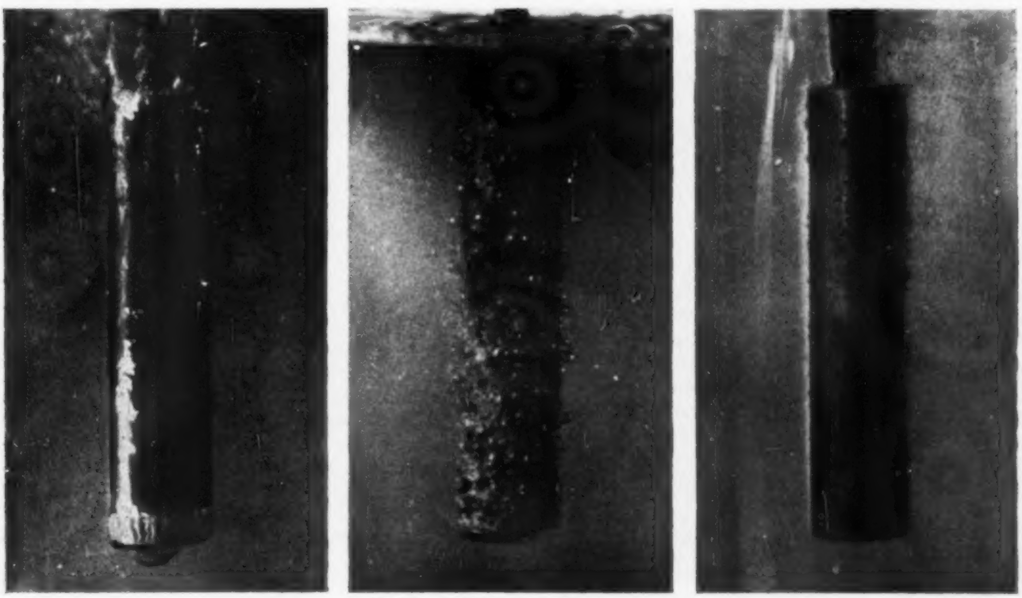
There have been claims that the fatty oil contained in compounded quenching oils improves the wettability of the oil and, therefore, enhances quenching. These claims have not, however, been fully substantiated and, in any case, the disadvantages of having fatty oil present outweigh any slight improvements gained.

(4) *Mineral-base Quenching Oils:*—Crude petroleum, from which mineral oils are produced, are complex mixtures of hydrocarbons, mainly paraffins, naphthenes and aromatics, in varying proportions, depending on the nature of the crude oil and the refining process used. After the light fractions, gasoline, kerosene, light diesel fuel, etc., have been removed by distillation, the lubricating oil feedstock is subjected to one or more vacuum distillations, in order to divide it into a number of ' cuts ' of various viscosities. These ' cuts ' are refined to remove unstable constituents and thus to improve the resistance of the oil to oxidation.

Refining is carried out, either by conventional means, or by solvent processes, or both. In the conventional process the oil is treated with a small quantity of concentrated sulphuric acid, which reacts with unstable constituents, the reaction products being removed as sludge. Traces of acid left in the oil are neutralized by alkali and the refined oil is given a final polish with activated earth. Solvent refining consists of treating the oil with selective solvents, such as liquid sulphur dioxide and furfuraldehyde, and thus removing the less stable and more reactive hydrocarbons. Solvent refining produces oils of high oxidation stability.

Distillate oils refined in these ways can be blended together in suitable proportions to give a complete series of lubricating and similar oils, covering a wide range of viscosity. Oils of suitable viscosity, containing both conventional and solvent refined distillates, can be selected from this range for use as quenching oils.

When certain waxy paraffinic crude oils are distilled, oils of high viscosity are left behind as residues. These form the basis of most tempering



(*a*) (*b*) (*c*)

Fig. 2.—(a) Vapour blanket stage A; (b) vapour transport stage B; (c) convection cooling stage C

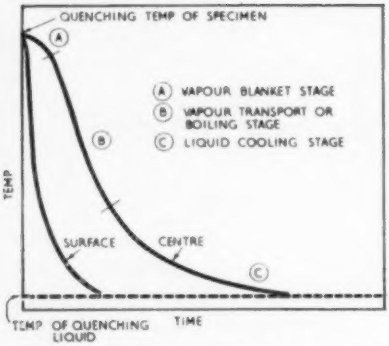


Fig. 1.—Cooling curve representing the change in temperature of a steel specimen quenched from a high temperature

A stage, the steel specimen is surrounded by a blanket of vapour formed by the liquid as a result of the large amount of heat given out by the specimen. This vapour is a relatively poor heat-transfer medium and, therefore, cooling during this stage is slow.

The second stage, B, begins when the temperature of the specimen is such that the heat evolved is not sufficient to maintain a continuous blanket of vapour. During this stage the liquid has access to the surface of the specimen and a stream of bubbles rises, with the result that cooling is rapid.

The third stage, C, commences when the generation of the vapour ceases and the quenching liquid is in contact with all parts of the surface. Cooling during this stage of the quenching operation is by convection currents in the liquid and is, therefore, relatively slow.

An efficient quenching medium should have as short an A stage as possible and, in order to obtain full hardness, the rate of cooling within stage B must exceed the critical cooling rate of the material being treated. As there is always a risk of cracking after the beginning of martensite formation, it is usually desirable to have a slow rate of cooling within stage C.

The three stages of quenching can easily be observed by quenching a specimen in a glass container. Fig. 2 (*a*), (*b*) and (*c*) show three shots taken from a film of a quenching operation carried out in a special apparatus. Fig. 2 (*a*), 4 sec. after the start of the quench, is from the vapour blanket stage A; Fig. 2 (*b*) after 30 sec., from the vapour transport stage B; and Fig. 2 (*c*), after 50 sec., from the convection cooling stage C. It will be evident that stage A and, to some extent, stage B, are governed by the boiling point or distillation range of the quenching liquid. Both stage B and stage C are dependent on the specific heat, thermal conductivity and viscosity of the liquid.

Quenching Fluids

(1) *Water and Aqueous Solutions:*—In most hardening operations, either water, solutions of various salts in water, or oil is used as a quenching medium. By virtue of its high specific heat, water has a high cooling power and, consequently, gives a fast rate of quench. Water, however, has a troublesome A stage, mainly because of its low boiling point and the ease with which it forms an insulating vapour blanket. In addition, it cools the work-piece so rapidly in the C stage that in many hardening operations there is a risk of cracking. The essential merit of water and aqueous media, apart from cheapness and easy availability, is their high cooling power in the B stage, which makes them very useful for shallow-hardening steels and plain carbon steels with high critical cooling rates.

Brine and caustic soda solutions are used in practice, but to a lesser extent than oil or water. Aqueous solutions give an even faster rate of quench than plain water, but they are not often used, as the risk of cracking is too great. It is believed that, at the moment of quenching, crystals of the dissolved salts are precipitated round the work-piece and that these tend to dissipate the vapour blanket, thus shortening stage A and boosting stage B.

(2) *Molten Metals, Fused Salts and Gases:*—For special hardening operations, fused salts, molten lead, etc., are used. They are used occasionally for high-speed steels and for martempering. Air is the quenching medium for air-hardening steels which, on account of their high alloy content, have low critical cooling rates. Quenching is carried out in a blast of air and this mild treatment ensures very low distortion.

(3) *Fatty Oils:*—Prior to the use of mineral hydrocarbon oils, fatty oils such as whale oil, sperm oil, rapeseed oil and cottonseed oil were used widely as quenching media and their use increased with the development of alloy steels. However, compounded oils, *i.e.* mineral oils blended with varying amounts of fatty oil, and ultimately straight mineral hydrocarbon oils, have gradually superseded fatty oils.

All fatty oils are compounds of carbon hydrogen and oxygen and most of them consist principally of mixtures of the glycerides of a number of fatty acids, such as stearic oleic, palmitic, etc. Most fatty oils have low viscosities, about 60 to 90 sec. Red. 1 at 140°F., and suitably high flash points, which make them very good quenching oils. Their main disadvantage, however, is their poor resistance to oxidation. After a short period of use there is

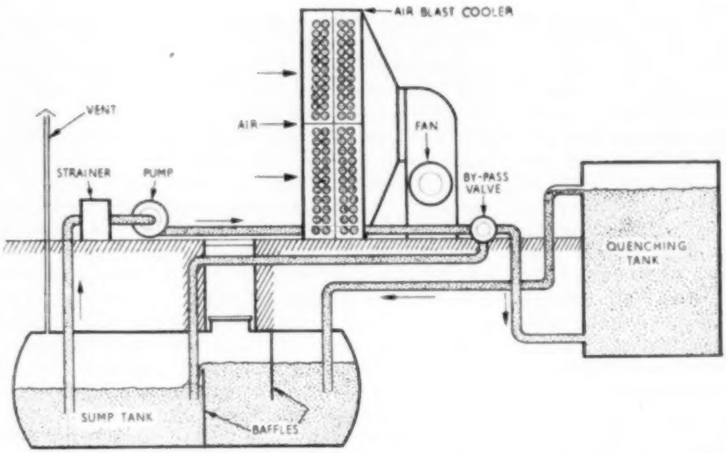


Fig. 3.—Typical layout of a quenching-oil system

the percentage of heat given up in the early stages, the more efficient is the quenching fluid. The test itself consists in quenching a standard specimen into a given volume of oil and observing the rise in temperature after a given period, say 5 sec. A similar test under identical conditions is then carried out, with the object of determining the ultimate rise in temperature of the oil bath when the specimen has been fully quenched. The relationship:—

$$\frac{\text{Temperature rise after 5 sec.} \times 100}{\text{Ultimate temperature rise}}$$

gives the percentage of heat removed in the first 5 sec. The principle can be used to determine the heat removed at any stage of the quench. This is quite a sensitive method of differentiating between quenching oils and can give valuable data on the properties of oils at any stage of quenching.

End-quenching hardenability tests have also been studied as a means of evaluation. The best known of these is the Jominy test, in which hardenability is measured by directing a jet of water against the end of a steel bar heated to hardening temperature and measuring how the hardness drops along the length of the bar. By using various quenching oils on bars of the same steel and comparing the hardness results, theoretically the method could be used to evaluate oils. It is, however, not sufficiently discriminating, probably because the spray breaks down the vapour blanket and so masks any significant differences.

The above-mentioned tests are all simple in principle, but considerable care is necessary to ensure repeatability. Techniques of this kind are used in researches to ascertain the influence of various factors, such as type of oil base, physical properties, presence of additives, etc., on quenching performance, but the most reliable practical test is the metallurgical test carried out on specimens comparable in size to industrial work-pieces.

Practical Handling of Quenching Oil

The range of size in oil-quenching equipment can vary considerably from tanks of a few gallons' capacity, using static oil, to installations holding several thousands of gallons of oil and equipped with pumps, etc., for circulating the oil through coolers to control the temperature. Tanks with static oil, cooled by water jackets or internal water-cooling coils, may be adequate for small hardening shops, but where the throughput of work is considerable and the work-pieces are large, it may be desirable to pump the quenching oil round an external circuit containing cooling equipment. This may be either the ordinary tubular heat exchanger using water as the cooling medium, or the atmospheric cooler, in which the oil passes through pipes cooled by an air-blast. In addition to the cooler, the external circuit will include a pump and a strainer to remove large solid contaminants, such as scale, from the oil. It may be advisable on occasion to provide a sump tank to serve as a reservoir of cool oil and to facilitate cleaning of the system.

For some purposes, the oil is heated or refrigerated to keep its temperature within some preferred temperature range. Usually, however, the temperature can be allowed to fluctuate between 20 and 70°C., since the quenching efficiency of oil, unlike that of water, does not vary to any great extent with reasonable changes in temperature. In the case of water, a maximum temperature of about 30°C. is essential for best results, otherwise the temperature of the bath is too near that of the boiling point of water (100°C.), with the possibility of the formation of steam and the prolongation of the vapour blanket stage. Sometimes a moderately hot oil quenching bath is preferred as it reduces even further the risk of cracking during the convection cooling stage of quenching.

On the subject of introducing the work-piece into the quenching bath, movement is nearly always

oils and, being residual oils, they have low volatility and high flash point which are necessary for the operation of tempering.

In order to select a suitable straight mineral oil for use as a quenching fluid, we must study the requirements of the operation.

The factors governing the dissipation of heat from the work-piece are specific heat, thermal conductivity, latent heat of evaporation and viscosity. These factors, however, with the exception of viscosity, do not differ appreciably from one mineral oil to another, nor are there any appreciable differences, except in regard to viscosity, as between mineral oils and fatty oils. There is a wide range of viscosity from which to choose and, as a rule, the lower the viscosity of the mineral oil, the faster is the rate of quench. The fastest rate of quench possible is to be desired, but the lower viscosity oils are more volatile and this factor must be taken into consideration when a quenching fluid is being selected. High volatility can prolong the vapour blanket stage in quenching and, in addition, loss of volatile matter brings about an increase in the viscosity of the oil, thus reducing the rate of quench of the fluid after a short period of use. On the other hand, oils of higher viscosity and lower volatility can shorten the vapour blanket stage and give a faster quench. Beyond a certain point, these advantages can be more than offset by the fact that high viscosity can hinder the turbulent escape of vapour in the vapour transport stage, stage B in the cooling curve. Although high viscosity means lower losses by volatilization, it also means greater drag-out losses.

In addition to shortening the vapour blanket stage, low volatility, *i.e.* high flash point, means that there will be less tendency for the quenching oil bath to catch fire, although, within reasonable limits of flash point, this factor is not so important as might appear at first sight. It is rare for quenching baths to exceed a temperature of about 70°C. (160°F.) and this is far below the typical flash points of quenching oils. Combustion does not take place under normal working conditions, as the quenched work-piece is surrounded by air-free vapour as soon as it is immersed in the quenching bath.

Because of the various conflicting factors, some average range of viscosity must be chosen and for most purposes a viscosity of about 50 to 70 sec. Red. 1 at 140°F. is very suitable. For very large work-pieces, a heavier oil with a viscosity of about 110 sec. Red. 1 at 140°F. is often preferred. Considerable latitude, however, can be allowed, according to circumstances. Table I gives characteristic properties of several grades of mineral oil suitable as quenching media.

A factor of great importance in choosing a quenching oil is resistance to oxidation. This governs the useful ' life ' of the oil and, for this reason, well-refined oils are chosen as quenching media. Under the combined effect of exposure to air and heat in service, quenching oils tend to oxidize, forming organic acids and other oxidation products. Some of these are soluble in the oil, whilst others are insoluble and may be precipitated as sludge. All these oxidation products tend to increase the viscosity of the oil and may ultimately affect its quenching power. The advantage of highly-refined oils is that they are much less susceptible to oxidizing influences and they can, therefore, retain their quenching power for very long periods, aided, of course, by the normal replenishment that is necessary from time to time, in order to replace ' drag-out ' losses. Even so, less highly-refined mineral oils often have long useful lives.

TABLE I.—*Properties of various grades of mineral oil*

Oil	Sp. Gr. at 60°F.	Flash point		Fire point, °F.	Visc. Red. 1. at 140°F., sec.
		Closed, °F.	Open, °F.		
1	0·890	400	420	460	70
2	0·892	400	425	465	110
3	0·895	340	355	390	50
4	0·925	370	390	420	95

Evaluation of Quenching Oils

A considerable amount of work has been carried out on the evaluation of quenching fluids, especially oils, and this includes the testing of new refinery products and a study of the effect of various additives.

Quenching power is usually assessed on a comparative basis by examining characteristic cooling curves of a metal specimen in the oils to be evaluated. The best known method is the silver ball test, where a 1-in.-dia. silver ball is quenched from the hardening temperature into the oil under test, and its rate of cooling measured. Comparison of the curves for different oils enables them to be assessed for suitability as quenching fluids. Silver has the advantages that it does not form scale on heating and that it has no thermal change points which would, of course, affect the shape of the cooling curve to some extent. This test is not a clear guide to the behaviour of large work-pieces, because the silver ball, small as it is, corresponds, due to its high thermal conductivity, to an even smaller steel specimen. A more practical test, therefore, is to use a small cylinder of austenitic stainless steel which, like silver, does not undergo thermal changes during cooling.

A useful and simple test is the interval quench test, the object of which is to find the relation between the time from the start of quenching and the amount of heat lost by the steel. The higher

imparted to the work-piece. This ensures that there is some agitation and that the steel does not remain in locally over-heated oil. It also helps to break the vapour blanket formed in the first stage of cooling. The simplest method is hand-agitation, the parts being held in tongs, but for mass production small parts may be allowed to fall through the quenching oil on to powered moving conveyers at the bottom of the tank. Even for quite large components, completely automatic systems are being used for mass production work. The furnace charge, carried in trays, may be fed out over the adjoining quenching tank, then lowered into the oil and removed automatically when cold. Provision can be made for transfer from furnace to quenching tank to take place in an inert atmosphere, thus avoiding scaling and decarburization.

It is not easy to estimate with precision the minimum volume of oil necessary for quenching a given throughput of steel, since various factors are involved, such as size of work-pieces, methods of cooling the quenching oil, etc. A useful guide is to have at least one gallon of oil per pound of steel quenched per hour, and up to double this amount is used quite commonly. Whatever the system employed, it is always advisable to have an ample quantity of oil, as this makes the plant more flexible and reduces the risk of overheating and of fire. A typical layout of a quenching-oil system is shown in Fig. 3.

TEMPERING OF STEEL

Metallurgical Considerations

Tempering involves reheating hardened steel to a temperature below that of the critical range of the steel and holding it at that temperature for a suitable time, followed by cooling at a suitable rate. The steel is, therefore, partially softened and quenching stresses which might otherwise cause cracking in service are removed. Depending on the nature of the steel and the size of the part, the duration of tempering may vary from 5 to 30 min. The rate of cooling in tempering has no effect on structure or hardness, but as rapid cooling may induce stresses in the material, it is the usual practice to cool in air. Certain alloys require faster cooling in oil or water.

Tempering Oils

The full tempering range extends from about 180 to 650°C. or sometimes even higher. Mineral oils cannot be used for the higher temperatures, but oils of specially high flash point are usable up to about 300 to 320°C. When the desired tempering temperature is higher than this, various types of forced circulation air furnaces, molten metal and molten salt baths are used.

When an oil is to be used for tempering, it is desirable that it should have as high a flash point as possible. The use of high-quality residual oils with low asphalt contents will ensure that volatilization is low, fuming is kept down to a minimum, and also that sludging and consequent thickening of the oil is retarded. If thickening occurs, circulation is hindered and the result may be uneven tempering. Even the lowest tempering temperatures cause rapid deterioration of the oil and the useful life is very short, much shorter than in the case of quenching oils. If thermal decomposition is to be avoided, slow heating up of the oil in the tempering bath is necessary, otherwise local overheating takes place. The high viscosity of tempering oils when cold is no drawback, since they become very fluid at tempering temperatures, thus permitting rapid circulation to attain uniform tempering of the work-pieces and minimizing losses by drag-out.

Characteristic properties of typical tempering oils are given in Table II.

Oil tempering baths are of simple construction, the oil being contained in steel pots heated either externally by gas or oil, or internally by electric immersion heaters. The pots are surrounded by thermal-insulated casings. They are not large in size, as oils, like molten lead and salts, are best suited to tempering small components. The work-pieces are immersed, either hung on wires or carried in baskets or perforated ladles, for specific periods, removed and cooled in a manner appropriate to the steel. Where cracking of the work-piece is feared, it is advisable to bring oil and work-piece together up to the required temperature, but this is not often necessary. In most cases, satisfactory uniformity in temperature is produced by the convection currents in the liquid bath, without need for agitating the oil.

MARTEMPERING

The term 'martempering' is rather misleading, as the operation known by this name is virtually a quenching operation. The principle is to quench steel from a suitable temperature to one just above that at which martensite begins to form. The steel is held at this temperature for sufficient time to enable the temperature throughout the work-piece to become uniform and it is then cooled in air,

TABLE II.—*Properties of two typical tempering oils*

Oil	Sp. Gr. at 60°F.	Flash point		Fire point, °F.	Visc. Red. 1 at 200°F., sec.
		Closed, °F.	Open, °F.		
1	0·905	500	545	610	155
2	0·908	545	615	700	250

which results in the formation of martensite. By allowing the work-pieces to come to an even temperature throughout while still austenitic in structure, so that martensite forms only during subsequent slow cooling in air, little or no stress is produced in the cooled work-piece. Tempering may be carried out afterwards, treating the work-piece in the same way as one hardened in the conventional manner.

As the temperature at which martensite begins to form is in the region of 300 to 350°C., the quenching medium for martempering operations must be maintained at this level. It is impracticable to use mineral oil at such high temperatures, as thermal decomposition would take place and a fire risk would exist. Molten salts or molten metals are normally used in true martempering operations.

The main object of martempering is to prevent cracking and distortion of the work-piece and similar results can be obtained by a 'hot quenching' operation. The work-piece is quenched to temperatures below that at which martensite begins to form and some success has been achieved with oils maintained at temperatures between 100 to 200°C. As the operating temperatures are high, suitable oils should possess high flash points and good oxidation stability. The incorporation of a high-temperature anti-oxidation additive in the oil can be beneficial.

TESTING OF HEAT-TREATMENT OILS

Unused Oils

Mineral quenching oils give long and satisfactory service, because of their inherent resistance to deteriorating influences and also because quenching baths are being continuously replenished with new oil, due to inevitable losses. The deterioration which does occur is not dangerous to work-pieces or equipment, so that frequent and careful testing is not really necessary. In any case, it is not easy to suggest suitable and simple laboratory tests which will give a proper indication of behaviour in service. With tempering and martempering oils, the conditions of usage, *i.e.* sustained high temperature in contact with air, are so severe that the working life of the oil is inevitably short.

In general, it is customary for heat-treatment oils to be purchased on the supplier's recommendations, but if it is required to check the physical characteristics, then it is usually sufficient to determine flash point (closed and open) and viscosity, and to examine the oil visually for clarity and freedom from suspended matter. If it is desired to confirm whether or not the oil contains fatty material, the saponification value may be determined. Tempering and martempering oils are normally free from fatty material, which is not desirable for these applications, since it is unstable and readily forms carbonaceous deposits at high temperatures. Quenching oil for use with salt baths should be free from fats for reasons mentioned earlier.

There is no standard test for the volatility of heat-treatment oils and, although tests are sometimes carried out on quenching oils by heating a sample in an oven to temperatures of about 150 to 200°C. and measuring the loss in weight over a given period, repeatable results are obtained only if temperature conditions in the oven are carefully controlled. Quenching conditions vary so much that, at best, volatility measurements can only be a rough indication of the behaviour of the oil in practice. Information on volatility can also be obtained by determining the distillation or boiling range. In this test the initial boiling point and the percentage of oil recovered at various temperatures are recorded.

Resistance to oxidation is an important property of quenching and tempering oils and many laboratory tests have been devised for measuring this property. It is, however, a common experience with oxidation tests that they do not correlate with practice. Modifications of one oxidation test, in which air is blown through the oil at high temperature under controlled conditions, can be used on occasion to study the oxidation characteristics of quenching oils. Table III gives the results obtained by subjecting four oils to an oxidation test in which air was passed through the oils, maintained at a temperature of 120°C., at the rate of 10 litres/h. for 100 h. The viscosities of the oils were measured before and after the test, and also the amount of insoluble sediment which had been formed.

TABLE III.—*Results of oxidation tests on four oils*

	Solvent refined mineral oil A	Solvent refined mineral oil B	Conventionally refined mineral oil	Sperm oil
Kinematic viscosity at 100°F. centistokes:				
Before test ..	47·4	15·2	30·8	21·4
After test ..	51·2	15·8	39·0	2190
Ratio of final to original viscosity	1·08	1·04	1·27	102·3
Sediment insoluble in I.P. spirit—after test—%wt.	<0·01	<0·01	0·06	<0·01

The figures show the superiority of the solvent-refined oils over the conventionally refined oil and sperm oil, a typical fatty oil, in maintaining a more consistent viscosity. Such a test places the oils in order of merit, but it should be remembered that there is always a difference between an arbitrary

laboratory test and practice. Conventionally refined oils have long effective lives in practice, where the temperature of the oil is not maintained at 120°C., where air is not bubbling through them and where they are being replenished continually with new oil to replace drag-out losses.

Used Oils

Regular examination of quenching oils in service is not really necessary, but where information on the condition of the oil is required, it is usually sufficient to determine viscosity, flash point, insoluble sediment, neutralization value and water content. The tendency in service is for the values of the first four properties to increase and comparison with the figures for the unused oil gives an indication of the extent to which deterioration has taken place.

The deterioration of oils in use is accompanied by a rise in acidity, due to the formation of acidic oxidation products. In some applications development of acidity makes an oil unfit for further service, but this does not apply in the case of heat-treatment oils. Acidity has no relation to quenching properties and its measurement has no value, except to indicate how far the oil has deteriorated in use.

Contamination of quenching oil by water tends to reduce its quenching power because the water intensifies the vapour blanket stage of cooling. Water can also cause frothing in quenching tanks, with overflowing of the oil and consequent fire risk.

Tests on tempering oils are rarely carried out and they are, in most cases, examined visually to assess the extent of thickening and sludging. When the oil has become so viscous that drag-out is excessive, and when there is obviously a heavy precipitation of insoluble sludge, then the oil should be discarded and a fresh charge put into the oil pots after the latter have been cleaned out. The same remarks apply to martempering oils, where heavy sludge accumulations will, in time, give rise to unsatisfactory hardening and local overheating in the oil container.

Development

It will have been evident from the discussion on cooling curves and the properties of mineral quenching oils, in comparison with those of water, that the ideal quenching medium should possess:—(*a*) The short vapour blanket stage A characteristic of oils; (*b*) the rapid rate of cooling within the vapour transport stage B which is given by water; and (*c*) the slow rate of cooling within the liquid convection stage C which is a feature of oils.

It has been found that the quenching speed of mineral oils can be increased appreciably by the incorporation of various special additives. These oils are generally referred to as accelerated quenching oils, but although the increase in quenching speed can show improvements in special cases, these oils are still slower than water in the vapour transport stage. There are obvious advantages in prolonging the life of the oil in ' hot quenching ' operations and the use of high-temperature anti-oxidants in oils for this type of work has been attended with some success.

Additive-type quenching oils always contain a very high proportion of straight mineral oil and, therefore, their general behaviour, as regards consumption, deterioration, etc., is very similar to that of straight mineral oils.

DIFFERENTIAL ANNEALING

Improved Deep-drawing Technique for Aluminium

DEEP-DRAWN aluminium products, stronger and in some cases cheaper than those previously available, may now be produced by using sheet material that has been specially prepared by a process known as differential annealing. This process, now in operation at Northern Aluminium Co. Ltd., controls the temper distribution across a blank in such a manner as to make greater cupping reductions possible and at the same time to give a stronger product than can be obtained using a uniformly annealed blank. The technique is at present being used mainly in the quantity production of large rectangular blanks over 40 in. sq. for fish-handling boxes, but is suitable for shaped blanks or circles having a minimum diagonal length or diameter of 15 in. and a maximum length or diameter of 54 in.

A considerable amount of research has been carried out in the past few years to establish an understanding of deep-drawing processes. Differential annealing was developed following large-scale laboratory investigations into the problems of the reduction of blanks by deep-drawing. It is well known that the base of a shell made from a soft blank remains essentially soft, whilst the strength of the wall increases gradually from base to top rim due to the work hardening of the metal in drawing. It was established experimentally that, by taking an initially hard blank and annealing the rim only, the stronger base permitted greater cupping reductions.

Differential annealing is based on these principles and, by annealing a blank so that the distribution of retained hardness is inversely proportional to the distribution of the work-hardening pattern obtained in cupping, a container of uniform hardness (that of the material in the heavily work-hardened condition) is obtained; also bigger reductions in cupping and re-drawing are obtained.

The increased hardness in the base and the more uniform hardness overall of a box drawn from a differentially annealed blank has been demonstrated by hardness surveys conducted on fish boxes made from both differentially annealed and untreated blanks. Fish boxes are now being produced in large quantities from differentially annealed blanks; these are much more robust than those used previously and so are more able to withstand the heavy handling received in the landing and loading bays of the fishing industry.

Milker pails may also be made from differentially annealed aluminium blanks; these will not only be stronger but may be drawn in one operation instead of two.

Accurate Weight Calculation

Some Observations on the First Stage of Estimating in the Forging Industry

P. J. NIBLETT and R. O. PARRY, G.I.M.E., Grad.I.Prod.E.

IN the forging industry estimating is of prime importance. Evidence of this lies in the fact that estimating provides the whole basis upon which the business of producing forgings is transacted. The first step in the preparation of a quotation calls for an accurate calculation of the net weight of the forging in question, and it follows, therefore, that this calculation should be as accurate as possible.

The existence of weight-calculating tables ensures that no problem arises in the case of simple geometric shapes: rounds, squares, etc. It is only when called upon to deal with more complicated figures that any difficulty is encountered. Even then, an experienced estimator or weight-calculator can overcome some of these obstacles by means of interpolation. Also, there is the planimeter to deal with areas of irregular periphery.

There are, however, many cases which can be covered neither by the planimeter nor the interpolative efforts of the most experienced estimator. Interpolation, however knowledgeable, is by no means an assurance of accuracy, and the only dependable method of arriving at an accurate net weight is by *calculation*. Interpolation should be kept to an absolute minimum, and even use of the planimeter should be avoided where simple mathematics can be applied.

It is not suggested here that irregular areas should be resolved by the use of calculus where the planimeter is obviously a quicker and sufficiently precise method. It *is* suggested, however, that in the case of *volumes* which follow no tabulated geometric form, a little time would be well spent in evolving formulae to resolve these volumes. They should also, of course, be recorded in case they arise again.

Calculation of Volumes

An example of a well-known formula which can be beneficially substituted for interpolation is that of the boss or hub which takes the form of a conical frustum as in Fig. 1. Where the inclusive angle of the cone exceeds about 30 deg., multiplication of the mean diameter by the height does not give an accurate volume; this is given, however, by the formula:

$$\text{Vol.} = 0{\cdot}2618\ h\ (D^2 + Dd + d^2)$$

This, of course, must be multiplied by the appropriate conversion factor (*e.g.* 0·283 for steel) to give the weight in pounds, avoirdupois.

The volumes of large fillet and corner radii can be correctly assessed by use of another simple formula (Fig. 2):

Fillet radii (V_1) Vol. $= 0{\cdot}675\ r^2\ (D + 0{\cdot}446\ r)$

Corner radii (V_2) Vol. $= 0{\cdot}675\ r^2\ (D - 0{\cdot}446\ r)$

The size of radius at which these formulae should commence to be applied depends upon its

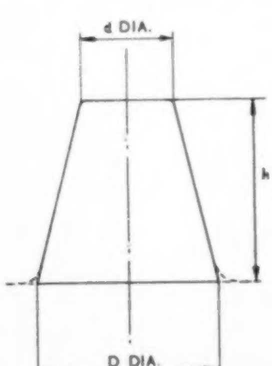


Fig. 1.—Volume of conical frustum

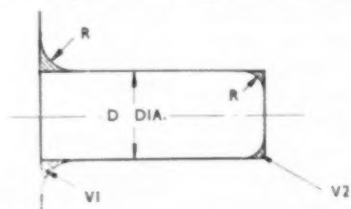


Fig. 2.—Volume of corner and fillet radii on diameters

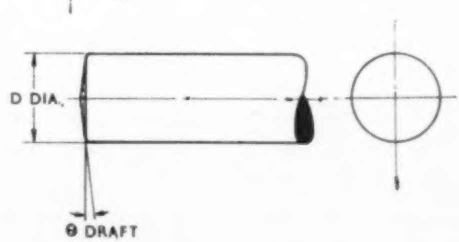


Fig. 3.—Volume of draft on diameters

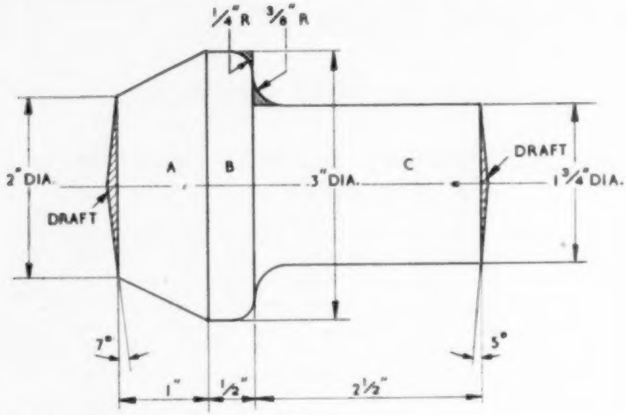


Fig. 4.—*Example of weight calculation*

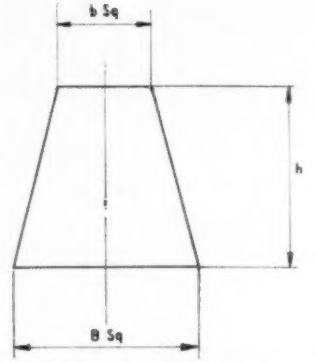


Fig. 6.—Volume of pyramidic frustum

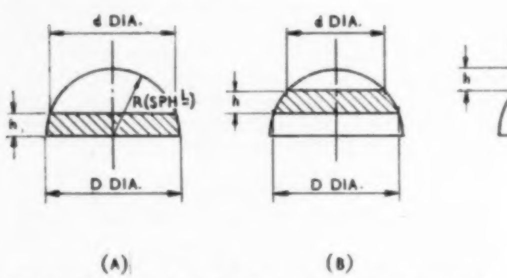


Fig. 5.—Volumes of spherical zones, (A), (B), and cap (C)

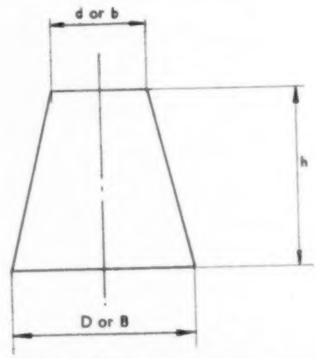


Fig. 7.—Weight of frustum of cone or pyramid using weight tables

relationship to the rest of the part, but, in any case, they should be used for radii of ¼ in. and upwards.

Table I with Fig. 3 shows formulae for the volume of draft on the ends of round shafts. Where the angle of draft differs from those shown in the table, the following general formula may be applied:—

$$\text{Vol.} = 0{\cdot}1666\ D^3 \operatorname{Tan} \theta$$

TABLE I.—*Volume of draft on ends of round shafts*

Angle of draft (θ)	Volume in cu. in.
3°	$0{\cdot}0087\ D^3$
5°	$0{\cdot}0145\ D^3$
7°	$0{\cdot}0204\ D^3$
10°	$0{\cdot}0293\ D^3$

While it is not the intention here to give the fundamentals of weight calculation, the example shown in Fig. 4 will demonstrate how even the simplest of weights can be calculated with maximum accuracy:

$A = 0{\cdot}2618 \times 1\text{ in.}\ (2^2 + (2 \times 3) + 3^2) \times 0{\cdot}283 = 1{\cdot}408$

$B = 3\text{ in. dia.} \times \frac{1}{2}\text{ in. (weight tables)} = 1{\cdot}000$

$C = 1\frac{3}{4}\text{ in. dia.} \times 2\frac{1}{2}\text{ in. (weight tables)} = 1{\cdot}702$

$\text{draft (A)} = 0{\cdot}0204 \times 2^3 \times 0{\cdot}283 = 0{\cdot}046$

$\text{draft (C)} = 0{\cdot}0145 \times 1\frac{3}{4}^3 \times 0{\cdot}283 = 0{\cdot}022$

$\text{fillet rad.} = 0{\cdot}675 \times \frac{3}{8}^2\,[1\frac{3}{4} + (0{\cdot}446 \times \frac{3}{8})] \times 0{\cdot}283 = 0{\cdot}052$

$4{\cdot}230$

less $\text{corner rad.} = 0{\cdot}675 \times \frac{1}{4}^2\,[3 - (0{\cdot}446 \times \frac{1}{4})] \times 0{\cdot}283 = 0{\cdot}035$

Total weight, in lb. (steel) $4{\cdot}195$

Although one cannot provide for all the odd shapes which are likely to occur from time to time, it is as well to be prepared, in advance, for some of the not so out-of-the-way shapes: part-spherical volumes, for example.

Fig. 5 shows three part-spherical examples: part (A) shows the zone of a sphere where it occurs

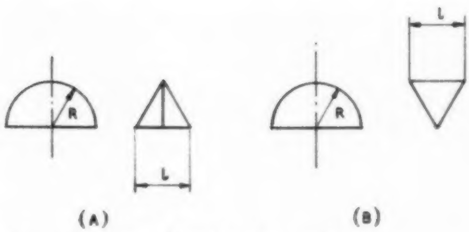


Fig. 8.—Volumes of semi-circular examples

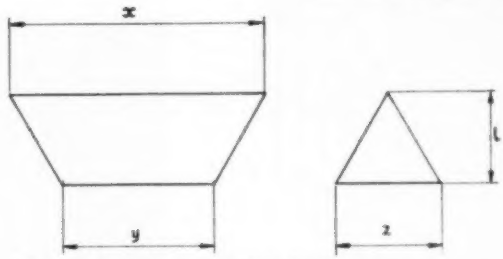


Fig. 10.—Volume of wedge-shaped prism

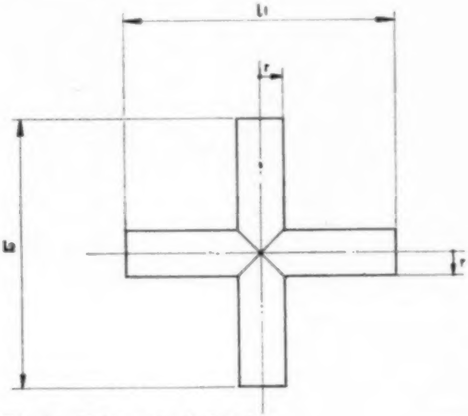


Fig. 9.—Volume of cylindrical cross

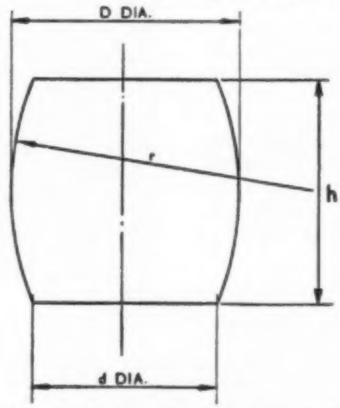


Fig. 11.—Volume of cask-shaped cylinder

either directly above or below the centre plane; part (B) shows a zone occurring in any plane, but where the radius of the sphere is not given and cannot, therefore, be included in the formula as a value. Part (C) shows the cap (segment) of a sphere.

$$\text{(A) Vol.} = \frac{3 \cdot 142 \times h\,(3r^2 - h^2)}{3}$$

$$\text{(B) Vol.} = 0 \cdot 524 \times h\,(\tfrac{3}{4}d^2 + \tfrac{3}{4}D^2 + h^2)$$

$$\text{(C) Vol.} = 3 \cdot 142 \times h^2\,(r - h/3)$$

$$\text{Or} = 0 \cdot 524 \times h\,(\tfrac{3}{4}d^2 + h^2)$$

Fig. 6 shows the frustum of a pyramid which, like the conical frustum may be calculated, where the angle is too large to make interpolation accurate:

$$\text{Vol.} = h/3\,(B^2 + Bb + b^2)$$

Weight tables can be used to calculate both conical and pyramidic frustums by the following method (Fig. 7):—

(1) Take (from weight-tables) 'h' length of 'D' dia. (or 'B' sq.).

(2) Take (from weight-tables) 'h' length of 'd' dia. (or 'b' sq.).

(3) Multiply (1) by (2) and square root.

The actual weight of the frustum is then the mean value of (1), (2) and (3).

Some of the formulae given here can, of course, be found in the more complete technical handbooks. Here are a few which have been evolved from the necessity for an accurate calculation of the volumes to which they apply:

The two shapes in Fig. 8 have been encountered quite frequently and resolved as follows:—

$$\text{(A) Vol.} = 0 \cdot 904 \times lr^2$$

$$\text{(B) Vol.} = 0 \cdot 667 \times lr^2$$

Another recurrent shape is the cylindrical cross in Fig. 9. Time may be saved, and greater accuracy achieved by using this formula:

$$\text{Vol.} = 3 \cdot 142 \times r^2\,(l_1 + l_2) - 5 \cdot 33r^3$$

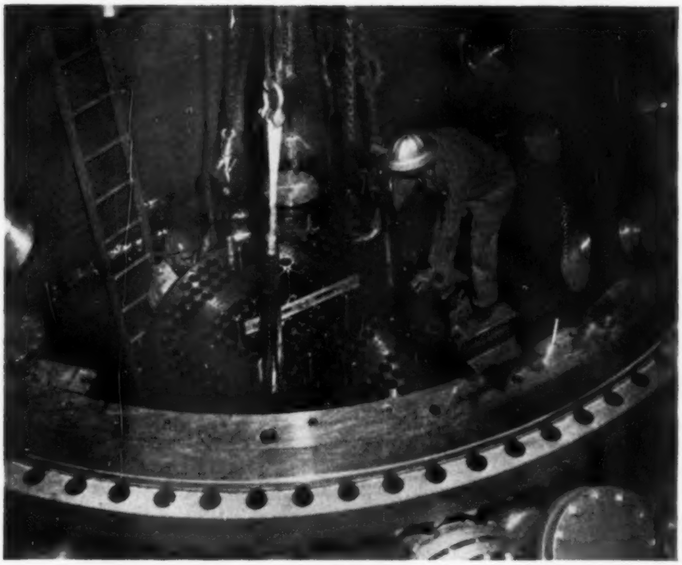
A less likely figure, but one which, nevertheless, has created difficulties is that shown in Fig. 10. This formula resolves the problem:

$$\text{Vol.} = \frac{(2y + x)\,zl}{6}$$

The cask or barrel-shaped cylinder in Fig. 11 is often met by the weight-calculator, and may be dealt with thus:

$$\text{Vol.} = 0 \cdot 2618 \times h\,(2D^2 + d^2)$$

In the event of a planimeter being unavailable, difficult areas can be calculated by the application



Building a Test Reactor

The engineering-test reactor grid plate being lowered into 35-ft.-deep pressure vessel at the National Reactor Testing Station, Idaho. Situated in an inner tank 27 ft. below the vessel's top head, the grid plate supports the reactor core assemblies and reflector pieces

THE construction of the new engineering test reactor at Idaho Falls, U.S.A., posed a number of metallurgical problems, especially in connection with the primary and secondary cooling systems. The primary coolant system contains demineralized water controlled to a purity approximately 1/2 p.p.m. dissolved solids at a *p*H of 6·0. The operating pressure is 200 lb./sq.in. at a flow of 44,400 gal./min. The temperature ranges from 110°F. inlet to 134°F. outlet. The basic requirement of this coolant is that it provides a safe, economic and compatible medium for cooling the aluminium-clad fuel plates.

An austenitic stainless steel was selected as the major material of construction for those pieces and assemblies which are in contact with the coolant. The basis for this and other specific material selections were discussed recently by T. E. Stephens, senior metallurgical engineer, Kaiser Engineers, a division of Henry J. Kaiser Co., at an industrial preview of the reactor.

Piping and Heat Exchangers

With corrosion a principal consideration, the materials of construction for the primary piping and heat-exchanger tubing could be either aluminium or austenitic stainless steel. Carbon steels, the low-alloy steels and copper-bearing alloys were eliminated from consideration because their corrosion products would contribute both to increased corrosion attack in the aluminium-clad fuel elements and aluminium-core components and to raising the level of long-lived activity throughout the system.

Aluminium alloys were given serious consideration as a major material of construction for primary coolant piping. The limitations to the use of aluminium were: (*a*) the higher fabrication costs due to their lower design stresses, this in turn demanding heavy wall piping; and (*b*) a considerably larger and more costly water purification system. Even with the low corrosion rate reported for aluminium alloys in high-purity water service (0·3 mil/year), calculations showed a sufficient corrosion product entering the system to require more extensive water purification, thus offsetting any advantage gained in the initial material purchase. For example, it was estimated that a stainless-steel system would require a 90 gal./min. flow capacity by-pass demineralizer, while the aluminium-tubed system would need a 700 gal./min. system. Such a demineralizer for an aluminium system was estimated at \$210,000 as against only \$45,000 for a stainless-steel system.

The use of carbon steel would result in an

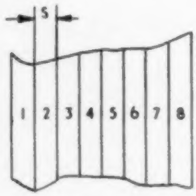


Fig. 12.—Simpson's rule

of Simpson's rule—a well-known and widely employed method.

Divide the figure up into any even number of strips at a common distance 's' apart. Draw ordinates to touch the boundary line of the figure (Fig. 12).

The area of the figure = s/3 (A + 4B + 2C)

Where A = The sum of first and last ordinates.
B = The sum of the *even* ordinates.
C = The sum of the *odd* ordinates (except first and last).

If cross-sectional areas are used instead of ordinates, the volume will be obtained. The more ordinates (or cross-sectional areas) taken, the more accurate will be the result.

Need for Close Estimation of Weight

Although it is difficult to envisage the advent of complete automation in the forging industry, the accent of the future will be, most certainly, on increased productivity and reduced costs. Both these happy conditions must ultimately arise from greater efficiency.

It is useless to imagine that modern plant, efficient layout or die-design of the highest order can make up for faulty or haphazard preparation. If costs have been based on an estimated weight which falls below the actual weight of the forging produced, the steps cannot be retraced and the budget is so much waste paper. On the other hand, the results of over-estimation are equally undesirable for obvious reasons. Accurate groundwork is as essential in the forging industry as in any other and accurate weight calculation is one way of ensuring that, at least, a good start is made.

Less Steel for Motor Cars in the U.S.A.

FROM Pittsburgh, Pa., comes last month's report that the motor-car industry is showing no indication of heavier steel buying despite the possibility of a strike in the automobile plants late in the spring. Production of motor cars is running about 20% under that of the early weeks of 1957. The automobile industry has revised downward by nearly 225,000 passenger-car units its projected production schedules for the first three months of 1958. Many assembly plants are idle or working on curtailed schedules as a consequence of lagging demand for 1958 automobiles. Mills producing sheet, strip and spring steel are hardest hit by the relatively low volume of business coming from the motor-car industry. Stainless-steel makers also are suffering a lack of business for the same reason.

Increased Use of Aluminium

The use of aluminium also is cutting into the motor-car manufacturing market to a greater extent than ever. Use of aluminium in automobiles has risen to an average of 52·40 lb. per car, or a record increase of 29% above use in the 1957 models. One automobile model contains 305·84 lb. of aluminium, contrasting with an average of 86·32 lb. in other models of the same make. One aluminium company official has stated that 25,000 tons of aluminium will be used for trim this year. Trim accounts for nine of the 52·40 lb. in the average 1958 automobile, contrasted with 5·6 lb. of the 40·0 lb. in the 1957 average model. Automatic transmission assemblies now utilize 19·75 lb. per average 1958 car, and engine parts account for 16·78 lb. If 5·5 million passenger cars are made in 1958, it is estimated that 144,000 short tons of aluminium will be used.

Although increased Government spending both for defence and civil projects is anticipated this year, many steel officials continue to pin their hopes on increased order volume from the automotive industry to pace improvement in finished steel markets. If a strike in that industry is averted, it is believed, steel demand will pick up late in the spring. Meanwhile, there is no evidence that the motor-car makers will try to step up production in anticipation of a strike. The powerful automobile workers' union remains a threat to peaceful settlement of forthcoming negotiations, however. The union has apparently scuttled its original idea of demanding a shorter work-week with no cut in pay. The latest proposal aired by the union president is a share-the-profit plan—promptly and strongly rejected by heads of the three leading automobile companies. Thus, until the forthcoming wage negotiations are resolved, the uncertainty in outlook for automotive steel demand is expected to continue.

Re-nitriding of Steel

(*Continued from page* 51)

nitride remains in the steel. However, resorting again to accepted theories, the nitride precipitate is 'over-aged' on heating to temperatures in excess of 500°C. (hence we cannot satisfactorily nitride at such temperatures). Thus it can be seen that, although aluminium nitride may not dissociate, it does not, of necessity, follow that it still can exert a hardening effect.

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(*To be continued*)

Reactor Vessel

The reactor vessel is constructed of carbon steel SA-212 firebox quality, grade B, clad with Type 304-ELC stainless steel. Nozzles or penetrations through the vessel for purposes such as fuel element unloading chute, inlet and outlet nozzles, are carbon steel clad with Type 304-ELC stainless steel.

Control Materials

It was necessary to investigate solid control-rod materials because the complex shape and many perforations of the ETR safety rod poison sections precluded the use of clad cadmium. Two materials evaluated were silver-cadmium alloy and a boron-stainless-steel alloy. The inadequate corrosion data available for the Ag-Cd alloy eliminated it from immediate consideration. The boron 18-8 stainless-steel alloy has adequate corrosion resistance; the main property in doubt is its behaviour under long-term irradiation conditions.

Canal Lining

The lining of canal walls was also the subject of considerable investigation. Such material must satisfy several requirements, as follows:—(1) In order to prevent absorption or entrapment of contaminated water, the lining should not have a porous surface, cracks or open seams. It should also have a surface that can be readily cleaned.

(2) The surface should be reflective to provide adequate illumination for the manual handling and observance of submerged parts and equipment.

(3) The lining should be resistant to radiation. This is necessary in areas where spent fuel elements will be stored.

(4) The lining material should be resistant to the slightly acidic canal water. This water is kept at a 6.5 *p*H to assist in retarding corrosion of fuel elements, reflector assemblies and other light metal parts which will be stored in the canal.

(5) This lining should also have adequate strength to resist damage by heavy handling equipment which will be in contact with the canal floor.

Materials evaluated for such service were paint (Amercoat and Carboline), ceramic tile, aluminium sheet, stainless-steel sheet, aluminium spray coating on mild steel and aluminium spray on concrete. The final selection was a Carboline paint, Phenoline No. 300, with stainless-steel sheet and plate on the floors where heavy contact wear is expected.

Grid-plate Forging

One of the major material problems encountered in the ETR programme was that of procuring an adequate grid-plate forging. This item is a large forged disc of Type 347 stainless steel 9 in. thick by 65 in. dia., weighing approximately 9,000 lb. Type 347 was chosen for this application by reasons of its slightly higher allowable working stress over Type 304-ELC material. In the finished condition, this plate is perforated with approximately 800 holes, and weighs over 6,000 lb. In service, the grid plate supports and establishes the spacing of the fuel element assemblies. Seventeen large rectangular holes in the plate are for the insertion of fuel elements, assemblies and other test materials. The combined load imposed by fuel elements and appurtenances plus the force of the coolant is calculated to be approximately 200,000 lb.

An indication of the difficulty expected in procuring this item is pointed out by the fact that, out of 14 suppliers invited to bid, only two firms submitted bids. The firm selected forged two grid plate discs from the same ingot, in this case a 45,000-lb. octagonal ingot, top poured and sand hot topped. Each disc was flattened and the corners bumped down to form a rough plate. Subsequent ultrasonic examination showed both of these discs to be defective in and around the central area.

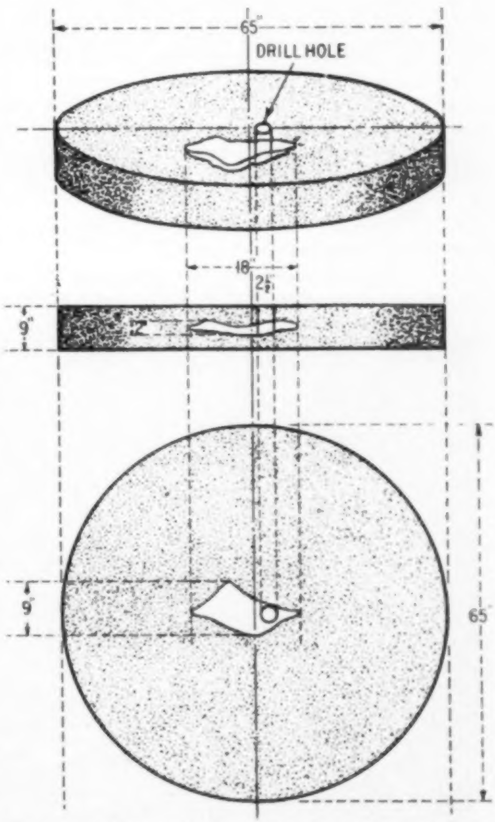


Fig. 1.—Defective grid-plate forgings as shown by ultrasonic inspection

economical system from the standpoint of initial material cost. However, the acidic *p*H of the system needed for aluminium-clad fuel elements would cause carbon-steel corrosion at a steady rate, thus adding iron to the coolant. This in turn would cause a considerable increase in the long-lived activity of the coolant, and also make water cleaners an expensive problem.

Carbon steel is used throughout the secondary system for piping and valving as the secondary coolant is not subject to neutron irradiation. This system can be chemically treated for corrosion inhibition.

The 18-8 Cr-Ni austenitic stainless steels have excellent corrosion resistance in water service. These austenitic stainless steels, when compared with aluminium alloys, have a higher design stress which will allow the use of relatively thin sections, thus resulting in lower fabrication and material costs.

Austenitic Stainless Steels

Two austenitic alloys were considered: Type 304 and Type 347. Of these, Type 347 (which has been stabilized with niobium) has been the more fashionable for reactor piping construction. This has been prompted by the possibility of inter-granular corrosion occurring in the welded or heat-affected areas of unstabilized alloys such as Type 304. The unstabilized austenitic stainless steels, when heated (as by welding) in the range between 800 and 1,500°F., tend to precipitate chromium carbide at the grain boundaries. It has been postulated that this migration and subsequent depletion of the chromium-rich constituent makes the metal immediately adjacent to the grain boundaries susceptible to corrosion. Another method of minimizing this condition is to provide a lower carbon content such as is obtainable in the Type 304 ELC stainless steel.

In other installations, stress-corrosion cracking has been noted in both Types 304 and 347; in fact, all the austenitic grades of stainless steel are susceptible to this cracking condition. It is apparently not dependent on a sensitized condition of the material but on the chloride concentration in the water.

There should be no stress-corrosion cracking encountered in the primary loop piping, but this should be considered as a possibility in the heat exchangers where there is exposure to raw or treated water on the secondary or shell side. High-chromium stainless steel is resistant to cracking, as are also certain other complex high-alloy materials. After lengthy discussions and literature searches relative to the concentration level of chlorides or the temperature wherein cracking would occur, it was decided that the initial selection of Type 304 would stand. The ETR exchangers use a shell-and-tube counter-flow arrangement with the primary water flowing through the tubes. The tubes and tube sheet are fabricated from Type 304 stainless steel with the heads of Type 304 stainless-clad carbon steel. The shell, which is exposed to the secondary water, is of carbon steel. As a result of careful design and fabrication, wherein pockets which might entrap chloride-bearing water have been minimized, the heat exchangers should give good service and be relatively free of stress corrosion cracking.

Since Type 347 is higher priced and does not have any appreciable advantage in rate of corrosion and has only slightly higher physical properties than Type 304-ELC, the latter was the first choice as a construction material in the ETR applications calling for a stainless steel.

All of the pipe welding was performed with 308 ELC lime-coated rods. It was not felt necessary to use inert gas in this piping application. Radiography of all welds was required in pipes 14 in. dia. and over.

In heavier sections, such as the reactor vessel, the use of carbon steel clad with an austenitic stainless steel layer on the surfaces exposed to the primary coolant was found to give optimum corrosion resistance along with a lower material cost. Several base materials and a variety of cladding materials are available. The base materials considered were SA-285 flange grade carbon steel and SA-212, grade B, firebox quality steel.

Pump and Valves

The ETR primary coolant system uses four horizontal centrifugal pumps. The pump bodies are fabricated from cast carbon steel. Corrosion products from these pump bodies do not contribute significantly to the amount of corrosion products entering the system, since the area of the bodies is exceedingly small compared to the entire system. Pump impellers are of an austenitic stainless steel, a material which is necessary here for its better erosion-corrosion properties. Also, the corrosion rate of cast steel in the ETR primary coolant was sufficiently low to ensure long life of components constructed from this material. This selection was based upon the economic advantage realized by carbon steel over the stainless alloys. A recent quotation for a 20,000-gal./min. carbon-steel pump was $32,000 as against $42,000 for the same pump in Type 316 stainless steel.

The large valves are fabricated from plates of Type 304-L austenitic stainless steel. A considerable economic advantage was realized in using a valve of this type rather than a cast valve.

General view of 10½-in. double-duo bar mill

Double-duo Bar Mill opened in Sheffield

Modernization at Sanderson Bros. & Newbould Ltd.

AS part of its general modernization programme, Sanderson Brothers & Newbould Ltd., Sheffield, is now bringing into operation a new 10½-in. double-duo bar mill made by the Brightside Foundry & Engineering Co. Ltd.

A mixed rolling programme of high-speed steels, tool steels and alloy steels, including steels for bright turning, will be handled. The mill is fitted with roller bearings and will roll to close dimensional tolerances. The double-duo design was chosen because of certain advantages not obtainable with three-high mills, including better size control, elimination of dead passes, and flexibility in operation. Wear on the top and bottom rolls of each pair of rolls in a double-duo mill tends to be even, whereas with the three-high mill the wear on the middle roll may be twice that of the wear on the top and bottom rolls.

In the new mill it will be possible to finish in any of the last three stands out of a roll train of five, and the floor is arranged accordingly. The maximum length of bars will be 60 ft. and sizes rolled will be from ⅜ in. to 1⅞ in. round, and equivalent bar sections and flats up to 3 ft. wide. Rolling speed is 300-900 ft./min. Two existing buildings have been joined to accommodate the mill and the general arrangement permits a ready transfer of finished material to the heat-treatment and bright bar departments.

The roll train comprises a reduction gear drive with input and output flexible couplings, combined mill pinions and diagonal gear set, five stands of double-duo roll housings and universal-type mill couplings. Provision is made for the installation of a sixth stand of rolls if desired.

Billet Heating and Treatment

For the time being, billets will be heated in a continuous-type pulverized-fuel-fired furnace which served the previous 10-in. mill. To maintain production, this mill has been kept in operation during the building of the double-duo mill. Once the double-duo mill is in full operation the old mill and its steam engine will be dismantled and additional billet furnace capacity added.

Live-roller gear is provided for the transmission of billets from the furnace to the roughing stand. Hot cogging shears are installed adjacent to the roughing stand for use when required.

(Continued at foot of opposite page)

Fig. 1 shows an outline of the defect as plotted by ultrasonic examination. Since the supplier would not accept ultrasonic indications as a basis for rejection, each disc was drilled through the defective areas and was found to have a large burst the size of a man's fist.

Corner Bumping during Forging

It was then decided to make two more discs. The technique this time was to pour another 45,000-lb. ingot, select a larger section from the bottom and flatten this, in essence working it out to a roughly square, flat plate 70 in. by 70 in. by 9½ in. thick, and then powder cut the disc from this plank. The principal forging difference on this disc was the elimination of the bumping down of the corners. The ultrasonic examination revealed a minor residual ingot centre line condition. However, by orientation of the final machining layout, the defects could be aligned along a neutral axis and this grid plate was considered to be adequate for the intended service. The second disc of this group was produced by the same corner bumping technique used for the initial two, as this was the only way to obtain a disc of suitable size from the smaller portion of the ingot. When this disc showed the same centre forging bursts as the first two, it was confirmed that corner bumping was the particular forging operation causing the defect.

This particular problem pointed out the definite advantages of ultrasonic inspection. Without this valuable tool, it is probable that many valuable hours of machine time would have been spent before uncovering the defective areas.

A question arose during the fabrication of the reactor vessel regarding the welding of a large nozzle into the stainless-clad vessel wall. These nozzles were specified as stainless-clad carbon steel. The vessel fabricator suggested that a solid stainless nozzle would be a more economical approach from a welding and materials standpoint. This raised the question of the relative merits of these materials, the major worry being that of differential thermal expansion between the solid stainless nozzles and the stainless-clad vessel wall. In order to resolve this, several fabricating companies were asked for an opinion; opinions were found to be split evenly. In one case, two employees within the same organization differed in their opinion. In the interest of complete reliability, it was decided not to risk the results of an extreme differential thermal expansion and to keep the clad-steel nozzles.

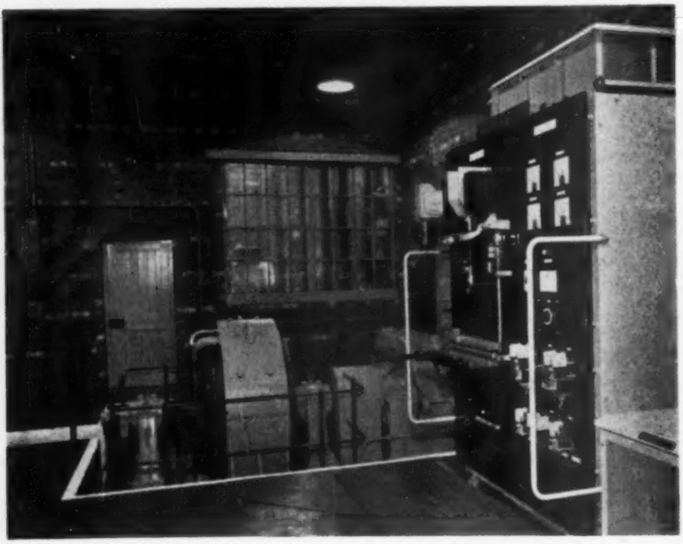
It is felt that the materials selected for ETR service will give adequate service under maximum operating conditions. Rarer materials such as hafnium, gallium or the liquid metals were not used; the only concession made was that of using boron 10 in control sections.

Double-duo Bar Mill

(*Concluded from opposite page*)

On leaving the hot shear, bars pass on to an outgoing live roller table. Bars and flats not requiring slow cooling or reeling are transferred to a straightening rack. Bars for reeling are transferred to a second rack and from thence to the hot reeler. Bars requiring furnace cooling are charged into a town's gas-fired temperature-controlled slow-cooling furnace, positioned opposite the end of the live roller conveyor from the shears. Other material for retarded cooling can be passed into a nest of slow-cooling tubes surrounded by insulating powder and cased in.

Finished bars will be removed by overhead crane to a despatch section at the end of the mill. Bars for hardening and tempering, normalizing or annealing will be placed on stillages arranged at the side of the bay in the finishing section. They will be picked up from here by the revolving charging machine in the adjacent heat-treatment department and charged direct into the heat-treatment furnaces.



Mill motor and control panel

induction process whereby the complete melting from raw materials and the subsequent casting of the ingot is carried out in an evacuated chamber. The laboratory has for many years operated a furnace of the induction type of 20-lb. capacity and, following the good results obtained from this furnace, a larger production furnace is being installed with a capacity of 600 lb.

Creep Testing

With the development of heat-resisting materials there has been a continually increasing demand for creep-testing facilities and there are now in constant use over 200 creep units. Fig. 2 shows part of a creep-testing laboratory; a travelling optical device permits the measurement of a deflection of a small mirror on each of the units.

Vacuum-melted Steel

The main advantage of vacuum-melted steels is their essential freedom from non-metallic inclusions and impurities. This feature alone greatly reduces the danger of failure of highly stressed components and gives improved ductility, notably in directions at right-angles to the grain flow.

Other advantages are:—(1) Control of gas content of the steel; (2) closer control of chemical composition; (3) ability to produce alloy composition which cannot be melted by conventional methods, thus opening up new fields for the development of super alloys; (4) improvement in mechanical properties of certain existing alloys; (5) reduced melting losses of certain elements; and (6) relative freedom from 'pipe' by vacuum arc melting.

These features suggest the kind of application where vacuum melting offers distinct advantages. In considering the main advantage of freedom from impurities, the following components are cases in point:—Ball races and bearings; compressor blades and discs; turbine blades and discs; high-grade polished sheet; certain tool and die steel applications where perfect finish is required; and fine-gauge quality steel wire.

A number of different Jessop 'Vacumelt' steel qualities have been evaluated on the basis of mechanical properties in comparison with the air-melted properties. The tests have included high-speed steels, bearing steels, stainless, ferritic creep-resisting and austenitic alloys. Tensile, creep and fatigue tests have been carried out. On the basis of all these tests, vacuum melting has given properties at least as good and in many cases greatly superior to those with air melting.

Taking two specific examples, a creep-resisting steel disc and an 18/4/1 high-speed steel, the following results were recorded.

Jessop H53 is a 12% chromium creep-resisting alloy. In the air-melted condition and when hardened to a tensile strength of 70 to 75 tons/sq.in. the longitudinal ductility is of the order of 15%, while the transverse ductility at the centre of a large forging may be as low as 5%. Tests from a 'Vacumelt' H53 disc forging at the same U.T.S. level showed longitudinal elongations of the order of 20% with central transverse elongations of 14 to 19%, *i.e.* three times the ductility in the worst position. The actual tensile results on transverse specimens from the central region of a 24-in.-dia. disc forging are given in Table I.

TABLE I.—*Tensile-test results on 24-in. dia. disc forging*

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
U.T.S. ..	72.8	72.6	72.8	73.8	74.0	73.6
Elongation % ..	16	17	14½	19	16	17½
Reduction of Area % ..	36	40½	40	58	55	53

A full and careful microscopical examination of this forging was made and the largest non-metallic inclusion to be found was only 0·003 in. long.

Jessop J3 is an 18/4/1-type high-speed steel which is being used among other things for high-temperature bearings. In the air-melted condition this alloy is comparatively free from impurities and it has a room temperature fatigue strength of ±40

Fig. 2.—View of Jessop's creep-testing laboratory

Vacuum-melted Steel, Titanium and Zirconium

Research at William Jessop & Sons Ltd.

Ultrasonic inspection of large titanium slab

ONE of the oldest established large steel companies in Great Britain, Wm. Jessop & Sons Ltd., have in recent years concentrated on the manufacture of steels and other special metals to particular requirements. With such a programme, comprehensive research facilities are needed and some 190 physicists, metallurgists, chemists, engineers and other technologists are employed in the company's research laboratories.

The present research department had its beginnings in the early 1930s when the existing works control analytical laboratory extended its activities to include some investigational work. Development was slow at first, but there followed a rapid increase in the size of the department when Jessop's entered the field of high-temperature steels and alloys, and the research staff now number approximately 6% of the total employees of the company.

In 1950, Whiston Grange near Rotherham was adapted as a research laboratory for long-term projects and 50 members of the research team are housed here.

Vacuum Melting

The consumable-arc melting process, whereby air-melted material is used as an electrode and remelted under vacuum, is used at Jessops to produce ingots weighing 30 cwt., and with the new plant being installed the company will be able to produce ingots up to 3 tons in weight.

Another method being used is the high-frequency

Fig. 1.—Vacuum induction-melting furnace

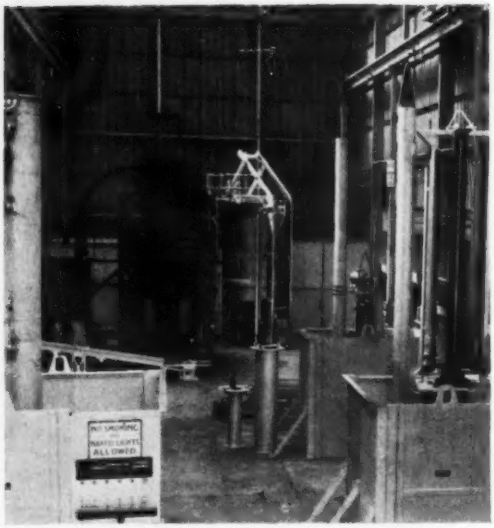


Fig. 3.—Titanium melting plant at Wm. Jessop & Sons Ltd.

tons/sq.in. for five million reversals. It is well known that an extremely high degree of purity is required in ball races to ensure long life, and vacuum melting this alloy improved this property considerably. Vacuum melting also increased the fatigue strength from ±40 to ±43 tons/sq.in.

Titanium

Production plant for titanium was designed and built by Jessops in 1954, and the company now markets seven brands of titanium and titanium alloys under the trade name of 'Hylite.'

Titanium must be melted in the absence of air as the liquid metal is so reactive that it quickly forms a solidifying mass of oxide. Even with quite small quantities of air present, enough oxygen may be dissolved to make the resulting metal hard and brittle. Jessops have adopted a double-melting technique using the ingot from the first melting as an electrode for the second melting, thus ensuring a homogeneous alloy with the minimum impurities present, *e.g.* the total hydrogen and nitrogen content of a typical melt would be only 160 to 170 p.p.m.

A small-scale plant is used in the laboratory to produce experimental ingots where the effect of variables may readily be studied. The electrodes are built up from pressed sponge in a similar way to that followed on the production scale and the double-melting procedure used to produce the final ingot.

Some details of the different grades of 'Hylite' are as follows:—

Hylite 10 and Hylite 15 are commercially pure grades of titanium with different hardness ranges, Hylite 15 having the greater tensile strength. Hylite 20 contains Al and Sn as alloying additions, and has greater strength than either of the above. Hylite 30 contains 2% Al and 2% Mn, and is recommended for forgings, etc., where reasonable strength is required. Hylite 40, with a higher strength and greater creep resistance than Hylite 30, is alloyed with 4% Al, and 4% Mn, and is suitable for compressor discs or blades. Hylite 45, 6% Al 4% V alloy, has strength slightly superior to Hylite 40, and is also weldable. Hylite 50 has been specially developed to have good creep resistance, and is a complex titanium-base alloy containing Mo, Si, Sn, and Al.

Zirconium

Zirconium production is akin to that of titanium in that the metal has a great affinity for oxygen and nitrogen so that the melting process must be carried out under vacuum. Zirconium, with a specific gravity of 6·5 (a little lower than steel), has its main application in atomic energy plant. Zirconium and zirconium alloys have good corrosion resistance and low neutron absorption value, and hence can be used to advantage within the region of the atomic reactor.

FURNACE FOR LIGHT ALLOY CASTINGS

A NEW, forced-air circulation furnace for annealing, solution heat treatment and ageing of aluminium-alloy castings has recently been installed by Royce Electric Furnaces Ltd., of Walton-on-Thames, Surrey, for Cambrian Castings Ltd., of Hirwaun, Aberdare. For the high-grade light-alloy castings produced by Cambrian Castings, a furnace having a close degree of temperature control and uniformity is essential.

The furnace is one of the standard range of VFC-type furnaces produced by Royce Electric Furnaces Ltd. in sizes from 10 in. dia. by 10 in. deep to 36 in. dia. by 60 in. deep; it may be used for tempering, preheating or similar heat treatment at temperatures up to 750°C.

To achieve close control and uniformity, high-velocity air circulation is passed over the heating elements housed in a baffled annulus surrounding the work chamber, the heated air passing through the charge on return. Heat is, therefore, transferred to the charge by forced convection, giving a uniform and rapid heating cycle. Heating elements are of 80/20 nickel chromium, suspended directly in the air stream and shielded from the work chamber to eliminate direct radiation. Air circulation is produced by a heat-resisting steel, high-velocity centrifugal fan unit mounted in the base of the furnace. The air impeller is designed to displace under all temperature conditions the maximum volume of air with widely varying conditions of pressure which may be imposed by different types of charge and density of loading. An air-cooled motor with a heat-resisting steel extended spindle gives a trouble-free performance for the combined duty of high speed and elevated temperature.

To meet A.I.D. requirements, the control gear includes an Electroflo automatic indicating controller and three-point recording instrument. A Delta-Star switch is included to reduce the rating to one-third for operation in the lower temperature range. An additional instrument is provided as an over-riding excess temperature cut-out.

Opening of New R.T.B. Staff College

View of the college at Stoke d'Abernon, Surrey

Training for Management in the Iron and Steel Industry

LAST month, Sir Edward Boyle, Bt., M.P., Parliamentary Secretary to the Ministry of Education, formally opened the new staff college belonging to Richard Thomas & Baldwins Ltd. at the Manor House, Stoke d'Abernon, Surrey.

In his speech Sir Edward mentioned that his father was at one time a director of Richard Thomas & Co. Ltd., which gave him a special link with the firm. He stressed the importance of the iron and steel industry, both in the matter of Britain's export trade and in the production of what economists called 'consumer durables,' that is to say motor cars and washing machines and similar items, which go such a long way to making life for the ordinary working family easier and pleasanter. Another important feature of present-day life, Sir Edward pointed out, was a greatly increased consumption of canned food, for good or ill, which again was impossible without the high productive level achieved by the iron and steel industry.

Concerning the political problems of the day, and the difficulties experienced by the steel industry in securing permission for large-scale investment, Sir Edward said that it was the Government's policy to 'contain' the present inflationary boom. It must be realized, however, that the rate of public investment was now running at a figure 37% higher than when this Government took office. But he would do what he could to see whether the new Chancellor might be able to give the necessary permission for many of the outstanding investment projects of the iron and steel industry, and Richard Thomas & Baldwins in particular, to go forward.

Finally, Sir Edward stressed the importance of the art and practice of efficient management and said that had he himself received a technical education the technology he would most like to have at his fingertips was that of metallurgy.

Importance of Training Foremen

Introducing the Parliamentary Secretary, Mr. H. F. Spencer, managing director of Richard Thomas & Baldwins, outlined the general scheme of training and instruction to be given at Stoke d'Abernon, and stressed that of all the levels of management found in productive industry that of the foreman is extremely important. Good foremanship, said Mr. Spencer, is the key to high production and the founding of the new staff college was primarily due to the fact that in the next few years some 200 to 300 new foremen have to be found and trained within the R.T.B. concern alone. In addition, the new staff college is intended to ease the present alarming shortage of university graduates by providing a training course within the company which, together with 'sandwich' attendance at

technical colleges, should by 1961 provide the type of man needed in management.

The educational work of Richard Thomas & Baldwins can be contained under three main headings: (1) The development and education of its present and future managers in order to ensure the succession; (2) finding and bringing into the company men of the right character, ability and qualifications; and (3) education and training its personnel.

Most of the work of education and training in R.T.B. is undertaken in its works in England, Wales and Monmouthshire. The company employs some 25,000 people, and more than 40 education officers, apprentice masters and instructors seek to meet their education and training needs. From these works will come those who are to study at the staff college.

In principle, anyone who works for the company is eligible to attend. A lad leaving school soon after his 15th birthday, selected for the junior operative training scheme, may later be chosen for the potential foremen's course and find himself at Stoke d'Abernon for the first three and the last three weeks of his seven months' training as a junior foreman. A craft apprentice, leaving school at the age of 16 and indentured for five years, who does well in his work and studies and becomes an engineer, can be selected for junior management training at the staff college.

Those in laboratories, accountancy or administration may be chosen for a management course. Graduates from the university, and student apprentices from public and grammar schools and from within the company, who are sent to universities or colleges of advanced technology, will, as part of their development programme, spend a period or periods at the Manor House. Finally, those already within the company, preparing for, or in positions of managerial responsibility, from junior managers to chief executives, will attend management courses of varying lengths.

The Manor House

Stoke d'Abernon is rich in historical associations, having been the ancestral home of a noble English family—the Vincents, baronets of d'Abernon—since the Middle Ages. Though its outward appearance is mainly Georgian, the house contains 14th-century oak timbers, some Tudor panelling, a George I staircase and a chimneypiece by Robert Adam. Its rooms are fashioned in some of the most gracious of English architectural styles, and many of them have been refurnished by the company as nearly as possible in their original manner. In this way the essential character of the Manor House has been preserved, whilst serving the purposes of a modern industrial staff college. In addition to its suitability in this connection, it provides the imponderables of tradition, history, proportion and beauty. Its setting, in an unspoilt part of Surrey, brings to students the peace and spaciousness essential to concentrated study. The link with the past, in an age which has been described as having little sense of history, has its undoubted contribution to make to the education of future managers.

Nor have the more practical aspects of the 'art of living' been neglected by the designers of the Manor House staff college. The furnishing and decor of the bedrooms, which can accommodate 24 students all told, has been carried out in the best contemporary style, but on a budget which should be well within the capacity of a young man, who, as well as being a future manager, may also be getting married and setting up house for himself at the same time. At the Manor House he can see for himself how the intelligent and tasteful use of wallpapers, floor coverings and soft furnishings can turn his house into a home to be proud of, rather than simply somewhere to eat, sleep and watch television!

CONTINUING GRAPHITE ELECTRODE SALT BATHS

SALT bath furnaces have been established for over 30 years as an efficient and, in some instances, the only practical and economic method of heat treatment. The Efco-Upton continuing graphite electrode bath, recently introduced in this country by Electric Resistance Furnace Co. Ltd., is based upon several years' research and proving tests by their associates, the Upton Electric Furnaces Ltd., Detroit, U.S.A. The main advantage of the continuing graphite electrode bath is the ability to renew electrodes without taking down any part of the furnace brickwork.

The electrodes consist of cylindrical graphite rods which are fed horizontally through opposing walls at the bottom of the refractory lining as they are consumed and whilst the furnace is still in operation. A fresh electrode can be attached to the screw feed device again without interrupting operation of the plant, so that the full life of the furnace lining can be utilized, an advantage which has not before been possible with submerged electrodes. Since the electrodes are submerged with the end faces only exposed to the salt, electrode wear is reduced to a minimum.

With the special high-temperature bricks used, a lining life of 12 to 18 months is achieved at high-speed steel-hardening temperatures, three years on neutral hardening up to 1,000°C., and on aluminium brazing a life of five to ten years is not uncommon. These lining bricks absorb a negligible amount of salt in comparison with conventional linings which absorb practically the same volume of salt as is contained in the actual pot. This point is of particular importance in high-speed and brazing baths where the salt (or flux) is a comparatively expensive item.

Another advantage is that, with the electrodes located in the very bottom of the bath, the entire exposed surface of the salt and operating depth is available as work space. Again, the absence of any metal, resulting in the presence of metallic oxides in the bath, facilitates maintenance of the neutrality of the salt in hardening operations and obviates premature breakdown of the flux in aluminium brazing.

News of the Month

FACTORIES INSPECTOR REPORTS FEWER ACCIDENTS

Legislation to Control Use of Radio-active Materials in Industry

CONTROL APPARATUS MANUFACTURERS' LUNCHEON

MANY distinguished guests were present at the annual luncheon given recently by the British Industrial Measuring and Control Apparatus Manufacturers' Association, at the Kensington Palace Hotel, London.

Among those present were Mr. S. P. Chambers, C.B., C.I.E., senior deputy chairman of Imperial Chemical Industries Ltd., and Mr. T. E. Goldup, president of the Institution of Electrical Engineers.

Speaking at the luncheon, Mr. Chambers said he thought that the number of small hand-run plants would become fewer, and as firms became larger and amalgamations occurred, the drive for industrial instruments and their better use would go forward. He mentioned Sir Alexander Fleck's report that the Windscale incident would never have happened if there had been better understanding of the instruments and if they had been more conveniently placed.

Mr. E. W. Wilson, chairman of BIMCAM, referred to the export record of the Association for 1957, in which it was expected that exports would exceed £15 million out of a total turnover of £35 million. He stressed that home trade was the basis of export sales and expressed the hope that this basis would expand with the anticipated increase of the export market when the European free trade area came into being.

Mr. Goldup, speaking in reply, said that the most important factor today in industry was accurate measurement and control, but there was an appalling shortage of technical manpower at all levels, and this was the greatest limitation on industrial progress.

At the luncheon: left to right—Mr. J. B. L. Munro, engineering division, Board of Trade; Mr. L. S. Yoxall, president of BIMCAM; Mr. S. P. Chambers, C.B., C.I.E., senior deputy chairman, Imperial Chemical Industries Ltd.; and Mr. Eric W. Wilson, chairman of BIMCAM

A RAPID growth in the industrial use of radio-active materials is referred to in the annual report of the Chief Inspector of Factories for 1956, published recently. (Cmd.329, obtainable from H.M. Stationery Office or through any bookseller, price 9s. 6d.)

'It has been increasingly felt,' states the report, 'that the use of radio-active materials (other than for luminising, which is the subject of existing regulations) should be brought under more detailed control.'

A committee has examined a draft code of regulations which had been in course of preparation, and as a result draft regulations in respect of sealed sources were nearly complete by the end of the year, and have since been published.

The regulations will cover all known industrial uses in current practice or projected in the future.

The accident rate was the lowest yet recorded, and non-fatal accidents showed a reduction for the first time in five years.

Efforts to reduce the risk of accidents due to fire were greatly intensified, and the aim has been to increase the use of precautionary measures which have not, up to the present, formed the subject of any measure of compulsion.

The Chief Inspector says that benefits to health are beginning to accrue from legislation of more general scope than the Factories Acts. The Clean Air Act, where it has reduced the pollution of the atmosphere, has had immediate repercussions on standards of cleanliness and lighting.

The Food Hygiene Regulations, 1955, also have stimulated food products factories and factory canteens to further effort in cleanliness.

The report says that in the field of safety, co-operation between manufacturers of equipment and machinery, occupiers of factories and the Inspectorate is improving.

Power Convention at Brighton

THEME of the tenth British Electrical Power Convention to be held at Brighton from June 16 to 20 will be 'Electricity and World Progress: Britain's Contribution.'

Sir George Nelson is to deliver the presidential address, and papers are to be presented by Sir Christopher Hinton and Sir Claude Gibb, among others.

MR. FELIX L. LEVY

DUTY-FREE CAMERA

A NEW automatic camera microscope, the first to reach this country, was delivered several days ago to Standard Telecommunication Laboratories Ltd., Dowlish Ford Mills, Ilminster, Somerset.

The instrument came from the non-profit making Carl Zeiss Foundation on a duty-free licence, and cost over £1,000. Called the Ultraphot II, there are less than a dozen in existence.

MR. FELIX L. LEVY

(*see facing page*)

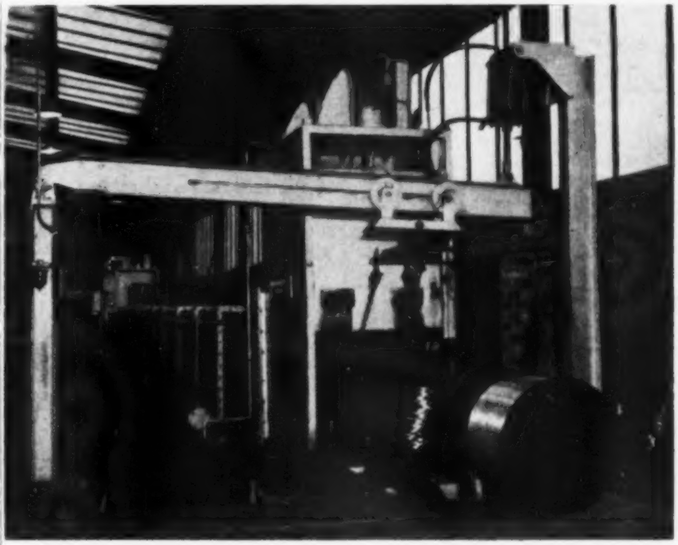
PRESIDENT of the National Federation of Scrap Iron, Steel, and Metal Merchants for 1957-58, Mr. Felix Levy is joint managing director of George Cohen Sons & Co. Ltd., a business that was founded by his great-grandfather in 1834 and is now the largest in the '600' Group.

Born in 1911, he was educated at University College School, at Clifton College, and in Paris. At the age of 17 he was apprenticed to the family firm and learned the business the hard way, being required to start at 8 a.m. and to work in all departments, including the scrap yard. After a few years he became a travelling representative, buying scrap in England and Wales, and the sound economic appreciation of the trade thus gained led to his appointment as manager of the company's branches in Birmingham and Sheffield.

In 1935 Mr. Levy was elected to the board of George Cohen Sons & Co. and he is now chairman of five companies and a director of 11 other concerns in the group, including the holding company—George Cohen 600 Group Ltd.

Since the Raw Materials Division (which includes a wide range of new and second-hand iron and steel products and the manufacture of many grades of iron powders) came into being under the direction of Mr. Levy, its turnover and the scope of its operations have rapidly increased. His record of Government service in the post of Assistant Director of Scrap Supplies in the Iron and Steel Control of the Ministry of Supply is well known and was of great value in a critical period. One example of the result of his specialized knowledge and efforts towards the end of the war was that over 60% of the nickel used in alloy steelmaking came from scrap recovery.

Mr. Levy is an active member of the Anglo-Jewish Community. An able public speaker, he combines a facility for clear thinking and expression with a keen sense of humour, which makes him a welcome guest at trade functions.



BRIGHT ANNEALING COPPER WIRE

An example of the growing use of automatic control in heat treatment is provided by a continuous furnace for bright annealing copper wire recently supplied by Metalectric Furnaces Ltd. to W. T. Glover Ltd., Manchester. The plant, which can handle wire in coils and spools up to 1,000 lb. in weight, is automatically controlled and can be operated by one man. The wire is loaded at floor level, so that the spools can be easily rolled on to the charging platform. Once there they are automatically tilted and placed directly on to the conveyor chains. So that the furnace is always fully loaded when handling coils, these are placed singly on the chains, instead of being stacked in carrier cages. When emptied at the discharge end, the cages are returned to the charge end by a roller conveyor.

The furnace, over 100 ft. long, can operate at temperatures up to 500 C. The protective atmosphere is conditioned town's gas. The output of the furnace is 44 tons per week; the rating is 135 kW., and the consumption of electricity is 58 kWh. per ton of wire annealed.

VISIT TO U.S. KANIGEN PLANTS

THREE people who left England by air at the end of last month for a three-week tour of the U.S.A. were Mr. L. W. Stubbs, sales director, Albright and Wilson (Mfg.) Ltd., Mr. A. H. Loveless, technical director, and Mr. A. McL. Aitken, technical sales manager, all of the company's 'Kanigen' department.

Itinerary of the visit includes Chicago, Los Angeles, Sharon (Penn.), Dunkirk (N.Y.), Buffalo and New York.

The group have had discussions with directors and senior executives of the General American Transportation Corporation and are visiting plants operating the 'Kanigen' process throughout the United States.

FURNACE ON FILM

A 16-mm. sound film on the 6-cwt. capacity carbon-rod resistor furnace which is installed at the experimental foundry of the British Steel Castings Research Association has been made by the Association's own film unit. Originally produced a few weeks ago to illustrate the inaugural lecture of the recently announced exchange series between the B.S.C.R.A. and the Steel Founders' Society of America, this 15-minute film describes in detail the construction and operation of a steel-making furnace that was the first of its type to be ordered for installation in this country. The film can be hired by non-members of the Association on application to the secretary at East Bank Road, Sheffield, 2.

STAFF CHANGES *and* APPOINTMENTS

Mr. D. D. Campbell has been appointed managing director (sales) of the **Metallurgical Equipment Export Co. Ltd.,** 19 Victoria Street, London, S.W.1, a consortium of companies engaged in the manufacture of steelworks plant. Through its associated company, Indian Steelworks Construction Co. Ltd. (Iscon), it is responsible for the general engineering work in connection with the Durgapur steelworks in India.

* * *

Foundry Services International Ltd., Long Acre, Nechells, Birmingham 7, announce the appointment of Mr. B. Howard Williams as general manager of their new associate manufacturing company to be established during the year in Sydney, Australia.

Foundry Services International Ltd. are a company within the Foseco Group concerned principally with the manufacture and supply of chemical and metallurgical preparations for the treatment and improvement of metals. Hitherto, Foseco have exported to Australia, but owing to trade restrictions the need to provide a means of meeting ever-increasing demands has become more and more obvious, and it has been decided to manufacture the range of Foseco products ' on the spot ' for Australia's expanding foundry industry. Mr. Williams is a member of the Institute of British Foundrymen.

* * *

Mr. R. F. Hayman, industrial gas officer of the **Gas Council,** 1 Grosvenor Place, London, S.W.1, has been appointed chairman of the industrial gas development committee of the Council in succession to Mr. W. H. Tarn, whose term of office as chairman of the committee expired recently.

* * *

Mr. R. J. Kingsnorth, M.I.E.E., A.M.I.Mech.E., has recently been appointed manager of the process control division of **Elliott Bros. (London) Ltd.,** Century Works, Lewisham, London, S.E.13, a member of the Elliott-Automation Group. Mr. Kingsnorth has been connected with the electrical instrument industry for over 25 years, and for the past 17 years has been manager of the Erith instrument factory of Salford Electrical Instruments Ltd.

* * *

Sanders and Forster Ltd., 3 Buckingham Palace Gardens, London, S.W.1, are to establish a Caribbean office at 31 Charlotte Street, Port of Spain, Trinidad, to work in close association with Lee Lum Ltd., the company's main Trinidad agents.

The Caribbean office will be controlled by Mr. P. C. Beckett and will be responsible for sales of a range of standard buildings and purpose-made structures throughout the Caribbean area, including the eastern seaboard of the United States and the northern countries of South America. The

Mr. P. C. Beckett

company hope to be able to provide the steel framework for low-cost housing.

Sanders and Forster Ltd. are one of the Chamberlain Group of Companies.

* * *

Mr. Spence Sanders has resigned the chairmanship of the **Fulmer Research Institute,** Stoke Poges, Bucks., on his retirement from the board of directors of Almin Ltd. His place as chairman has been taken by Mr. W. R. Merton. Mr. J. G. Graham has been appointed to the board of directors.

* * *

Mr. Douglas Dodds-Parker, M.P., has joined the board of the **Head Wrightson Export Co. Ltd.**

* * *

Mr. T. E. Potts has been appointed a managing director of the **British Oxygen Co. Ltd.,** Bridgewater House, Cleveland Row, London, S.W.1.

* * *

A branch office to be opened in Belgium shortly by **Evershed and Vignoles Ltd.,** Acton Lane Works, Chiswick, London, W.4, will be under the management of Mr. C. Samyn, who has for a number of years handled the company's products there.

The address of the new office will be: Evershed and Vignoles Ltd., Succursale, 142 Rue Gallait, Bruxelles.

* * *

The officers of the **Gauge and Tool Makers' Association,** Standbrook House, 2-5 Old Bond Street, London, W.1, for the past session have been re-elected for 1958.

* * *

Mr. Malcolm Turner Clark has been appointed chief chemist at the Cricklewood laboratory of **British Oxygen Gases Ltd.** He succeeds Mr. C. Coulson-Smith, who has retired.

Mr. Clark is aged 52 and has worked at the Cricklewood laboratory for the past 27 years. His activities recently have been concerned with the production control of acetylene.

* * *

Kelvin and Hughes (Industrial) Ltd. have appointed Mr. V. P. Scholes as area representative for the Midlands.

His address is ' Springcroft,' 152 Warren Hill Road, Erdington, Birmingham 23. Telephone Erdington 3856.

* * *

Mr. K. Druce, D.F.H., A.M.I.E.E., has been appointed manager of the Bristol office of the **English Electric Co. Ltd.,** responsible for the south-west England territory, in succession to Mr. T. Robinson who retired recently.

Following the retirement of Mr. I. Mackintosh, Mr. H. Granville-Brown, A.I.E.E., has taken charge of the Southampton office of the company, now in new premises at 29 Shirley Road, Southampton. Telephone: Southampton 28333/3.

* * *

The United Steel Cos. Ltd. announce the following appointments to the boards of three of their branch companies:

Mr. K. G. Lampson, managing director (sales) of United Steel, Lt.-Col. P. F. Benton Jones, managing director (mining and carbonization) of United Steel, Lt.-Com. G. W. Wells, director and general manager of Appleby-Frodingham Steel Co., and Mr. R. J. Bavister, commercial manager of Samuel Fox & Co. Ltd., have been appointed directors of Samuel Fox.

Mr. K. G. Lampson, Lt.-Col. P. F. Benton Jones and Mr. I. M. Kemp, chief design engineer of Appleby-Frodingham Steel Co., have been appointed directors of Appleby-Frodingham.

Mr. R. P. Crawshaw, general sales manager and chief purchasing agent of United Steel, has been appointed a director of United Steel Structural Co. Ltd.

(*Continued on page* 84)

MINERALS CONGRESS

THE Institution of Mining and Metallurgy will hold an international congress on mineral processing in London from April 6 to 9, 1960. It is proposed that the papers to be discussed should cover fundamental and applied research and development in the fields of mineral dressing, chemical processing, roasting, cyanidation, leaching and solvent extraction, but not smelting.

Enquiries should be addressed to the secretary at 44 Portland Place, W.1.

AUTOMATION IN NORTH AMERICA

D.S.I.R. Report Covers Twelve Industries

A REPORT on visits to industrial, commercial and research establishments in North America was published recently by H.M.S.O. for D.S.I.R., price 4s. 0d. (4s. 6d. by post), 72 cents U.S.A. Entitled Overseas Technical Reports No. 3, 'Automation in North America,' it is the result of six months' visit by a D.S.I.R. staff engineer to factories in the U.S.A. and Canada, covering 12 different industries.

The report gives a picture of a representative section of the engineering industries in North America—though others such as meat processing and plywood manufacture are included—and should serve as a useful companion to the report on automation issued by D.S.I.R. in May, 1956.

The author shows how the principles of automation have been rapidly adapted to practical use. There are many reasons for this and, apart from the well-known factors such as more h.p. per worker, two are notable: U.S. firms seem to employ on the factory floor more professional engineers of a high standard than industry in this country; and old machinery is scrapped as soon as it ceases to be the most economic way of doing the work, even if its capital cost has not been amortized.

Of outstanding interest is a description of the Chrysler Corporation's engine plant at Detroit, probably the most modern works of its type in the American motor industry. It was completed in October, 1955, and is an excellent example of co-operative planning. The engine designer, the production engineer and the plant engineer combined to provide the best possible layout.

In this factory engines are tested automatically. This is done in a separate bay with 72 test stands, where a whole series of operations are performed without human interference. For example, an empty stand is selected, the engine is moved into it, all oil, water and electrical connections are made and the engine is started up and run for 15 minutes. Afterwards, a signal lamp summons an inspector, who checks the engine for correct functioning, signs the inspection card and releases it on its journey.

BEILBY MEMORIAL FUND AWARDS

Applications Invited For 1957 Prizes

FROM the interest derived from the invested capital of the Sir George Beilby Memorial Fund, awards are made to British investigators in science to mark appreciation of records of distinguished work.

Preference is given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering and metallurgy.

In general, awards are granted as an encouragement to younger men who have done original independent work of exceptional merit over a period of years.

The Administrators, who represent the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Metals, are empowered to make more than one award in a given year if work of sufficient merit by several candidates is brought to their notice.

Consideration is to be given to the making of an award or awards from the fund for 1957. Outstanding work of the nature indicated can be brought to the notice of the Administrators, either by persons who desire to recommend the candidate or by the candidate himself, not later than February 28, 1958, by letter addressed to The Convener of the Administrators, Sir George Beilby Memorial Fund, The Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

The letter should be accompanied by nine copies of a short statement on the candidate's career and of a list of titles, with references, of papers or other works published by the candidate, independently or jointly. Candidates are also advised to forward one reprint of each published paper of which copies are available.

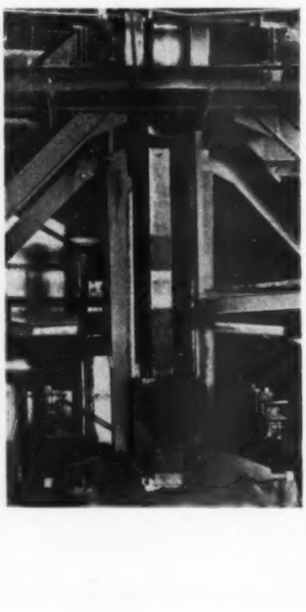
OBITUARY

Death of Mr. W. B. H. Gallwey

Gallwey: Mr. W. B. H. Gallwey died recently at his home in Cobham, Surrey. He was chairman and managing director, Union Carbide Ltd.; chairman, British Acheson Electrodes Ltd. (of Sheffield); chairman and managing director, Gemec Ltd., and Kemet Products Ltd., and a director of Bakelite Ltd. Mr. Gallwey was born and educated in Newcastle upon Tyne.

Whitney: Dr. Willis R. Whitney, 'dean' of industrial research in America, died recently at the age of 89, after a heart attack at his home in Schenectady.

In 1900 Dr. Whitney founded the General Electric Research Laboratory, and subsequently served as its director for 32 years, during a period of great technical advances.



ENDLESS BELT ?

SEEN on the left is a 6-ton Massey hammer installed at Ambrose Shardlow's works at Sheffield. Nothing spectacular about it except that the 11-in. × $\frac{5}{8}$-in. nylon belt fitted to it is still in good condition after $4\frac{1}{2}$ years' continuous service. The belting is made by Gandy Ltd. from material supplied by British Nylon Spinners Ltd., 25 Upper Brook Street, London, W.1. Nylon used for this purpose has considerably extended the belt's working life.

New Plant and Services

High-temperature Vacuum Sintering Furnaces

A new series of induction-heated high vacuum furnaces with temperature capabilities in the range of 2,000 to 2,600°C. has been developed by the vacuum equipment division of F. J. Stokes Corpn., Philadelphia, Pa., U.S.A. (Fig. 1).

With the increased upper-temperature limits, these furnaces are especially suitable for vacuum sintering of materials, such as tantalum compacts for electrical capacitors, or special high purity carbides.

A graphite, molybdenum or tantalum susceptor, depending on the application, is used to create high temperatures around the material being sintered. The susceptor is heated by a conventional induction power supply. Complete instrumentation for temperature control and recording is provided as a part of the system.

High vacuum operating conditions in the order of 0·1 micron and less are developed and maintained through combination pumping systems consisting of Stokes 'Microvac' mechanical pumps and 'Ring-Jet' oil vapour diffusion and booster pumps.

Units are available with uniform temperature work zones ranging in size from 3 in. diameter by 6 in. high to 8 in. diameter by 12 in. high.

High-speed Vertical Forging Press

The 500-ton high-speed forging press illustrated in Fig. 2 has been progressively developed over a number of years by Eumuco (England) Ltd., 12 Great Portland Street, London, W.1, and the latest assembly incorporates some new features already proved in other forging machines.

The drive units are of Lamberton design and manufacture with a caliper or 'disc' type brake giving excellent heat dissipation combined with long lining life. The brake is supported on two pins, and on withdrawal of one of these, swings clear of the disc so that the linings, bonded to steel backing plates, may be extracted without difficulty.

The drive to the machine is through a keyless clutch embodied in the flywheel. Other noteworthy features are an adjustable back-stop to limit piston travel, a wear indicator, and bonded linings.

Air-operated ejectors are fitted to the ram and die table, with provision for three ejector pins at the lower station. The electro-pneumatic control system to the ejectors permits timing of the ejector blow for any part of the press cycle. Ejectors may be held in the 'up' position for a few seconds after the press has stopped, to allow the operator time to remove the forging before it drops back into the die. The operation of the ejectors can be selected to occur at every second or third stroke of the cycle.

In construction, the press is a one-piece steel casting having shrunk-in tie bars. A load meter reading in tons has been provided, and this can be a most useful guide to a die setter making the first forgings of a batch. The meter can be easily removed from the frame when not required.

An automatic lubrication system with a motor-driven pump is interlocked with the main motor starter, and other controls allow inching in both forward and reverse directions for setting purposes. A wedge below the die table is equipped with a calibrated pointer to show the amount of vertical movement of the die table during adjustment.

Allowance has been made for automatic feeding of the forging through the various die operations, and the units have been designed to provide fast, continuous production.

Reticular Aluminium-tin

The production of a new type of bearing alloy has been announced jointly by the Tin Research Institute and the Glacier Metal Co., who have been working together for some years on its practical development.

The new bearing alloy contains about 20% of tin, the remainder being aluminium hardened with from 1 to 3% copper. The tin constituent

Fig. 1 (below).—A high-temperature vacuum sintering furnace, one of a series recently developed in the United States

Fig. 2 (right).—A 500-ton high-speed forging press with drive units of Lamberton design

Forthcoming Events . . .

February 26

Institute of Metals (General Meeting). 'Fuel efficiency in the melting and thermal treatment of metals.' Opening address by F. C. Ashen (I.C.I. Ltd.) and P. F. Hancock (Birlec Ltd.). 10.30 a.m. All-day discussion at the College of Technology, Gosta Green, Birmingham.

Manchester Metallurgical Society. 'Metallurgy of tantalum, niobium and beryllium,' by G. L. Miller, at the Central Library, Manchester, at 6.30 p.m.

March 4

Institute of Metals (S. Wales Section). 'Metals for high temperature service,' by W. Betteridge. 6.30 p.m. at the University College, Singleton Park, Swansea.

Institute of Metals (Oxford Section). 'Nucleation and the cast structure,' by V. Kondic. 7 p.m. at the Cadena Café, Cornmarket Street, Oxford.

March 6

Institute of Metals (Birmingham Section). 'The metallurgy of steel for deep drawing and pressing—Part II,' by A. J. K. Honeyman. 6.30 p.m. at the College of Technology, Gosta Green, Birmingham.

Institute of Metals (London Section). 'High-purity iron,' by B. E. Hopkins. 6.30 p.m. at the Institute's premises, 17 Belgrave Square, London, S.W.1.

March 10

Institute of Metals (E. Midlands Metallurgical Society). 'Continuous casting of steel,' by a member of the staff of BISRA. 7.30 p.m. at the College of Art, Green Lane, Derby.

North - east Metallurgical Society. 'Recent advances in metallography,' by D. McLean. 7.15 p.m. at the Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough.

March 12

Manchester Metallurgical Society. 'Martensitic transformations,' by J. W. Christian. 6.30 p.m. in the Central Library, Manchester.

March 19

Powder Metallurgy Joint Group. 'Developments in the practice of compacting and sintering.' All-day informal discussion at Church House, Great Smith Street, London, S.W.1.

METALLIC BORIDES NOW AVAILABLE IN U.K.

A COMPREHENSIVE range of metallic borides is now available in the U.K., and Borax Consolidated Ltd., Borax House, Carlisle Place, London, S.W.1, say that they are now able to supply two series of borides, one of high chemical purity (not less than 99.8%) and the other comprising technical grades of minimum purity of the order of 99%.

Several borides of the more important metals, such as chromium, molybdenum and tungsten, appear either in one or both of the ranges as well as the borides of some of the less common metals like titanium, zirconium, vanadium, niobium and tantalum.

The 11 compounds in the pure series are dense, hard powders of average particle size of 10 to 50 microns, and the 14 in the technical series are finer, averaging 5 to 10 microns in particle size.

Two technical data sheets—one for each series—have been published by the company, listing the chemical analysis, specific gravity, melting point and hardness of each compound. The electrical conductivities, of some importance in certain applications, are also included.

News in Brief . . .

CONTINUING an unbroken run of steel production records for the sixth successive year, The United Steel Cos. Ltd. produced 2,903,809 ingot tons during the calendar year 1957, an increase of 217,973 tons over the 1956 figure of 2,685,836 ingot tons. In achieving this new high level of production, three branches—Appleby-Frodingham; Steel, Peech and Tozer, and Samuel Fox—exceeded their previous best steel outputs. Pig iron production was also a record at 1,813,044 tons, compared with 1,524,744 tons in 1956.

* * *

A NEW company, Crucible Steel International, S.A., with offices at 400 Bay Street, Nassau, Bahamas, has been established by the Crucible Steel Co. of America to serve the buyers of special steels in the world market. The new company will have definite allocations of Crucible's products for export.

* * *

THE Fédération Internationale des Ingénieurs et Techniciens de l'Automobile, 5 Avenue de Friedland, Paris-8E, will be holding its 7th international technical congress in Paris from May 19 to 28, 1958.

About 20 technical papers from authors of the eight European societies belonging to the Fédération will be presented and discussed.

* * *

THE foundation stone was laid in Bombay, India, recently for a new factory to manufacture the range of pneumatic power tools and plant developed by the Consolidated Pneumatic Tool Co. Ltd., 232 Dawes Road, London, S.W.6.

The new factory is expected to be completed about the middle of this year and will employ an all-Indian labour force of three or four hundred, many of whom are already being trained at the works of the parent company in Fraserburgh, Scotland.

A BRITISH company, Pye Ltd., Cambridge, has just completed what is believed to be the largest V.H.F. radio-telephone system in the world. It provides the Sui Gas Transmission Co. of Pakistan with 635 miles of communications from Karachi to Multan. A three-channel communications system has been in operation between Karachi and Sui since a large supply of natural gas was found at Sui some three years ago. The work was carried out in conjunction with Ericsson Telephones, of Beeston, Notts.

The communications system will provide the means of controlling the gas flow when the pipeline is completed. Gate valves are located at the radio repeater stations and, although at the moment the gas pressure at Sui is sufficiently high to enable the gas to reach Multan under its own pressure, it may ultimately be found necessary to introduce pumping equipment. This equipment will later be installed at one or more of the radio stations where communications and power are available.

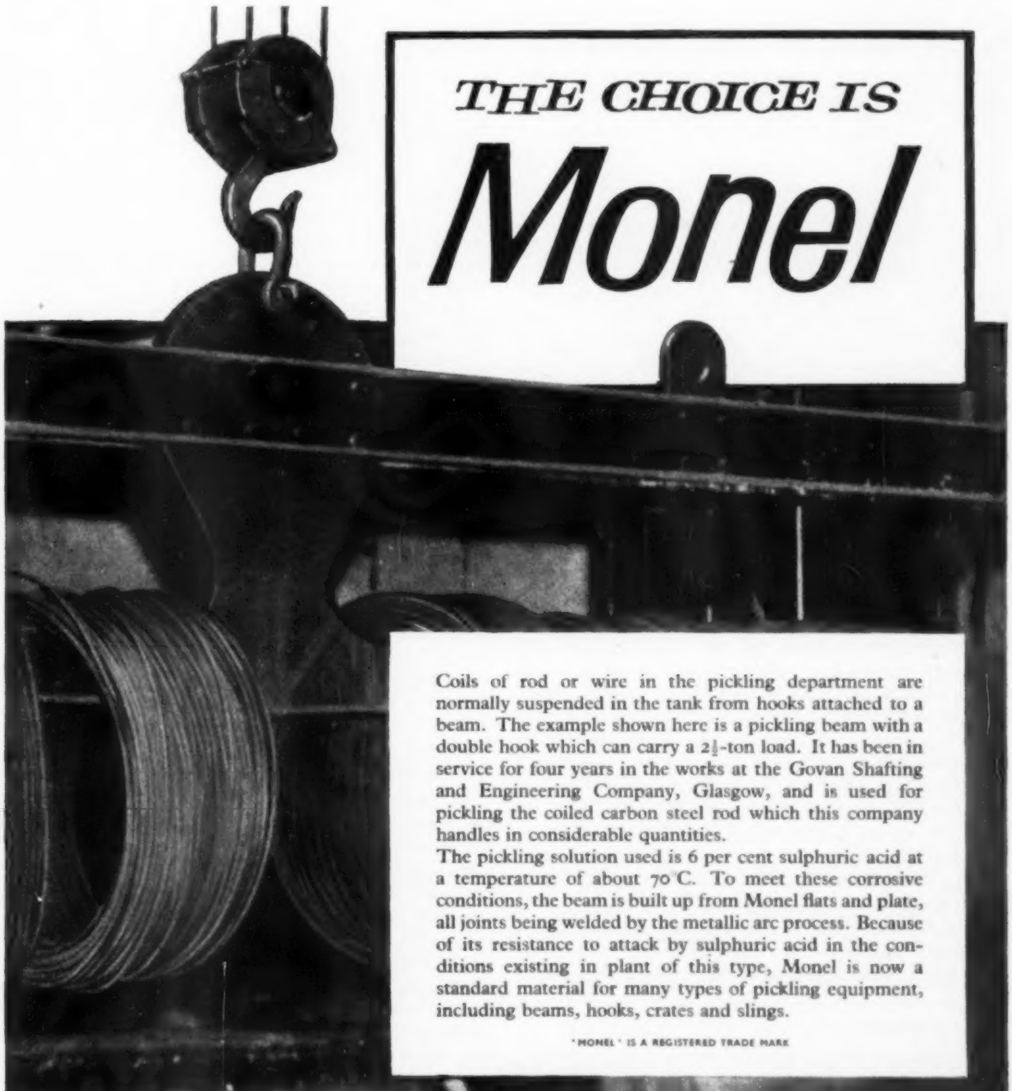
(*Concluded from page* 83)

Mr. H. B. Lloyd, technical services superintendent at Workington Iron and Steel Co. (a branch of United Steel) has left the company to take up another appointment. He has been succeeded by Mr. D. R. G. Davies, formerly chief chemist and control metallurgist. Mr. L. Jackson has succeeded Mr. Davies as chief chemist.

* * *

Mr. W. T. Vizer-Harmer, formerly director and commercial manager of Steel, Peech and Tozer (a branch of United Steel), has been appointed commercial director of the branch and has been succeeded as commercial manager by Mr. J. Mackenzie-Mair, who will be responsible for all commercial and sales matters.

For longer life in Pickling Plant



Coils of rod or wire in the pickling department are normally suspended in the tank from hooks attached to a beam. The example shown here is a pickling beam with a double hook which can carry a 2½-ton load. It has been in service for four years in the works at the Govan Shafting and Engineering Company, Glasgow, and is used for pickling the coiled carbon steel rod which this company handles in considerable quantities.

The pickling solution used is 6 per cent sulphuric acid at a temperature of about 70°C. To meet these corrosive conditions, the beam is built up from Monel flats and plate, all joints being welded by the metallic arc process. Because of its resistance to attack by sulphuric acid in the conditions existing in plant of this type, Monel is now a standard material for many types of pickling equipment, including beams, hooks, crates and slings.

'MONEL' IS A REGISTERED TRADE MARK

HENRY WIGGIN & COMPANY LIMITED, WIGGIN STREET, BIRMINGHAM 16

TGA CRIO

has a structure which is reticular within the continuous aluminium matrix, *i.e.* the tin has a structure which is itself continuous without disturbing the continuity of the aluminium. Should metal to metal contact occur between a shaft and a bearing that has this reticular structure there is an immediate supply of tin available at the surface to provide a thin, soft layer of tin over the aluminium, and thus inhibit surface breakdown.

The new alloy combines the strength of a continuous aluminium phase with the tin-availability of a comparatively heavy and continuous tin structure. It is claimed that when supplied in the form of steel-backed bearings, the alloy provides a better balance between the opposing demands of high fatigue strength and low rate of wear than any other known plain bearing. Furthermore, unlike copper-lead bearings, it needs no lead-based overlay plating to keep shaft wear in check.

A significant feature for large diesel engine applications is that since the alloy contains no free copper there is no danger of copper penetration of steel journals.

Reticular aluminium-tin bearings can, of course, be supplied prefinished, but since they have no overlay plating they can equally well be supplied semi-finished for boring in place, as is so often necessary or desirable in the case of large stationary diesel engines.

The bearings have already proved themselves in extensive road and test-bed trials carried out over the past three years, and some half-million bearings made from the new material are already in actual use.

A final point of some importance is that, as compared with copper-lead plated types, steel-backed reticular aluminium-tin bearings are cheaper to manufacture.

Gear Roll Tester with Graphic Recorder

A gear roll testing instrument, the 9R, recently introduced by David Brown Industries Ltd., Huddersfield, provides a simple, rapid and positive means of checking concentricity, tooth contact, centre distance and tooth thickness of a wide range of gears. The standard instrument, illustrated in Fig. 3, accommodates spur and helical gears up to 9-in. centres, while precise fitting and easily interchangeable attachments are available for shaft gears, bevel gears and worm gears.

Designed and built by the tool division of David Brown Industries Ltd., it is equally suitable for gear production in large or small quantities.

Fig. 3.—A gear roll tester, fitted with a graphic recorder, and an attachment to allow the standard instrument to accommodate shaft gears

Gears undergoing test are driven by a variable speed motor, the same power unit driving the recording head which automatically gives a full and permanent graph.

Errors are recorded on a dial indicator which is in contact with a sensitive carriage loaded by adjustable spring pressure. The dial is graduated to 0·0005 in. as standard, but 0·0001 in. graduation can be provided if required. Actual gear centre distances are read directly from the vernier scale at the front of the instrument.

The instrument is designed and built to ensure that the initial high degree of accuracy is maintained in use.

With an actual range of 0·008 in., a graphic recorder gives a magnification of 250 to 1; thus an actual error of 0·0002 in. is shown as 0·05 on the graph paper. The drive is arranged so that one revolution of the gear under test produces a graphical recording 12 in. long.

Drive from the variable speed motor allows the gear speed to range from ¾ to 2 r.p.m., the feed mechanism ensuring a positive relationship between gear and graph paper.

An ink reservoir of ample capacity feeds the recording pen arm, permitting use over considerable periods without attention.

An attachment to allow the standard instrument to accommodate shaft gears consists of a 'V' section pillar, located on the bed and carrying an adjustable top centre (this is shown fitted in Fig. 3). Units for bevel and worm gears are separately mounted on the sensitive carriage.

With this instrument, backlash in a pair of gears can be calculated by noting the difference between the working centre distance and the centre distance when the gears are in metal-to-metal contact.

Improvement to Portable Lubricator

The portable 'Knapsack' compressor, or grease pump, made by Tecalemit Ltd., Plymouth, Devon, has been improved recently by the lengthening of the shoulder harness and waist belt. It can now be worn by an operator wearing bulky protective clothing, for example, or for working in arduous overseas climatic conditions. The harness is now lighter and more flexible and is made of webbing straps.

The compressor has a large capacity, is hand-operated, and is engineered in knapsack form so that an operator can have both hands free for climbing, if necessary.

Designed for the servicing of a large number of nipples, the equipment consists of a vertical lubricant container having a base-mounted high-pressure pump connected through linkage to a long curved lever which passes over the operator's shoulder. The outlet steel-cored rubber-covered hose is fitted with a ball-jointed metallic flexible connection terminating in a Tat hook-on connector. The container, with a capacity of 9 lb. of lubricant and a standard delivery hose 5 ft. long, is mounted on a strong padded back-board provided with a stout shoulder harness and waist belt.

The compressor is designed for use with any good quality soft, self-collapsing grease.

robust, easily adjustable guide columns. These hammers, which can be erected in any part of the workshop, are equal to the most exacting requirements in respect of precision of forgings, while eccentric forging with multiple dies can be carried out without any danger of tilting the tup.

In addition to the belt-drop hammer, individual drives for board and belt lifts were exhibited, these being applicable for the modernization of old uneconomical hammers.

New ideas to enable them to meet the stringent requirements that a modern drop hammer has to satisfy have been adopted by J. Banning A.G., of Hamm/Westfalen, in the design of the Type GOA model exhibited. In addition to a high striking power, and either a rapid or a slow rate of striking to suit the work in hand, with a minimum power consumption, an extremely high degree of accuracy in working is now demanded together with a robust construction, and simple and labour-saving operation, even of the largest machines. The hammer can be driven by compressed air or by steam and, when the pressure is maintained, a high output and a high rate of striking can be maintained. The hydraulic valve control gear ensures high efficiency, a series of blows and individual blows being easily controlled. Large hammers can be controlled directly by the operator.

Classified Advertisements—Contd.

MACHINERY FOR SALE

MASSEY 5-CWT. PNEUMATIC POWER HAMMER. Overhanging type with slides. Longest stroke, 21 in. Number of automatic blows per minute, 140. Anvil set at an angle to accommodate long bars. Arranged direct motor drive. Complete with anvil. Centre to back, 18 in. Size of bar worked, 6 in. square. Weight about 6¼ tons. Photo, etc., from F. J. Edwards Ltd., 359 Euston Road, London, N.W.1.

PILKINGTON 2-CWT. PNEUMATIC POWER HAMMER for sale. Overhanging type. Without slides. Arranged for motor drive for 400/3/50. Hand lever or treadle control. Longest stroke approximately 17 in. Centre of ram to back 14½ in. Diameter of ram 9½ in. Weight about 3 tons. Photo, etc., from F. J. Edwards Limited, 359 Euston Road, London, N.W.1, or 41 Water Street, Birmingham 3.

CAPACITY AVAILABLE

HEAT TREATMENT—Aluminium alloy castings. Solution treatment up to 34 in. high by 30 in. diameter. Precipitation and stabilizing treatment up to 61 in. by 47 in. by 120 in. long. A.I.D. approved. Quick delivery and competitive prices. Enquiries to H. J. Maybrey & Co. Ltd., Worsley Bridge Road, Lower Sydenham, S.E.26.

Forging Presses and Hammers

German Machinery at Hanover Machine Tool Exhibition

As usual at the Hanover Machine Tool Exhibition, forging presses were among the exhibits at the display held last September. The following brief description is based on an account given in 'Export-Anzeiger,' Technical Edition, October, 1957

HORIZONTAL forging and swaging presses of the older type have vertically divided swages and dies difficult of access, the clamps carrying the dies being a comparatively long way inside the machine. This makes it difficult to insert components and to move them from one swage to the next. These and other disadvantages have been overcome in the design of the Eumuco horizontal forging and swaging presses, which are equipped with clamping collets, while the use of horizontally-divided dies and clamping collets ensures that the tools are easily accessible from three sides. The dies can easily be adjusted and replaced individually without dismantling any other part of the machine. The clamping force is adjustable by means of a handwheel.

The design offers the following advantages: Idle times for changing the tools are much reduced; the horizontal division of the dies makes the machines much more versatile and the improved access and better view of the work simplifies the feeding of the component and so increases the output. Further, a feed attachment to be fitted without difficulty. The machine has been equipped with an additional drive for the mechanical feeding of bar stock, the feed attachment being built on to the front of the machine clear of the tool section and easily supervised. Theoretically it is possible to feed a new bar at each stroke of the machine. In order, however, to enable the tools to be cooled sufficiently and blown out, in practice use is made of only every second stroke of the machine. If preferable, every third or fourth stroke may be utilized.

Drop Hammers

The belt-lift drop hammer, with its open design and simple friction drive, retains its importance in medium-sized and small drop-forging shops, and Beche & Grohs G.m.b.H., of Huckeswagen, have further developed this type of hammer, producing one with self-contained drive. The basic idea underlying the design was to keep the number of constructional components to the minimum, while achieving maximum strength and simplicity.

As a result a drop-forging hammer has been developed in which a belt is used in conjunction with a friction-lift mechanism with a pressure roller for raising the ram. The hammer is of rigid construction to ensure the accuracy of forgings, but flexible and resilient wherever important components have to be protected against the shock of impact. The anvil block, which can be supplied of either cast-iron or cast-steel construction, is provided with wide bearing surfaces on which the sheet-steel columns are secured by means of inclined sprung tie-rods. The ram, of special cast steel, has hardened and hard chromium-plated guide surfaces, and runs in double guide bars made of high-quality low-carbon steel. The head forms a separate unit connected to the columns by means of rubber mountings.

An important saving in space has been achieved by fitting a planetary gear employing hardened and ground pinions in the belt pulley. The gears are driven by a high-speed electric motor through a special flat belt and a flywheel. The hammer is arranged for operation by a smith and a hammer-man, this being the most usual practice at the present time. The pressure roller is controlled mechanically by hand. If the hammer is to be operated by one man, the head can be equipped with an additional hydraulic mechanism, which enables the machine to be controlled by means of a pedal, in which case the ram can be held and released in any required position through a foot-controlled hydraulic belt-clamping device. The power head of the Beche belt-lift drop hammer is a self-contained unit which, owing to its light weight and its space-saving design, can be fitted without difficulty to an existing drop-hammer frame.

Direct Drive and Adjustable Guides

Interesting innovations in the field of drop-forging hammers were displayed by Ludwig Gack of Muhlacker (Wurtt). A belt-drop hammer has an electric drive mounted on cast tup-guiding columns, provided with fourfold prismatic guides. The complete hammer, including the drive, is a self-contained unit. It can be operated by foot or by hand lever and can be supplied with or without a catching device for holding the tup at the top of its guide-way. As in drop forging, particularly with heavily stressed hammers, great importance is attached to simplicity of assembly, maintenance and operation.

The only important innovations are the direct drive, eliminating the heavy transmission gear, and

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Forge Foreman

AN opening is available with large engineering firm (Newcastle upon Tyne) for a foreman who will be required to take full charge of shop making medium forgings and drop stampings. Must be capable of making own estimates. Please give age and full details of experience and past employers, and state salary required. Write Box F.F. 102, *Metal Treatment and Drop Forging*.

METALLOGRAPHER is required in the G.E.C. Atomic Energy Division for work on a wide range of metals including steels, uranium and beryllium. Previous metallographic experience essential. Applicants must have completed or be exempt from National Service. Apply in writing, giving details of age, qualifications and experience, to the Personnel Manager, The General Electric Company Limited, Erith, Kent, quoting reference ML/14.

METALLURGISTS of degree standard are invited to apply for posts in the Materials Department of the G.E.C. Atomic Energy Division for work on the physical metallurgy of beryllium and uranium. Applicants should preferably have an interest in deformation, creep or fracture processes. Apply in writing, giving details of age, qualifications, experience and National Service commitments, to the Personnel Manager, The General Electric Company Limited, Erith, Kent, quoting reference ML/13.

MINISTRY OF SUPPLY require Chemist (Metallurgist) at Harefield, Middlesex, to take charge of High Temperature Materials Laboratory, with responsibility for high sensitivity creep tests, metallography of titanium and heat-resisting alloys, heat treatment and pyrometry. Qualifications: British of British parents. Hons. degree in Metallurgy or Associateship of the Institution of Metallurgists or equivalent. Considerable experience in Metallography and Heat Treatment essential. Experience in Mechanical Testing and Creep Testing an advantage. Salary: £755 (at age 25)—£1,180 p.a. Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting F.5/8A. Closing date, February 28, 1958.

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has a vacancy for a METALLURGIST in the Heat Treatment Section of its Technical Service Department at Oldbury, to work on salt bath methods and heat treatment of ferrous metals.

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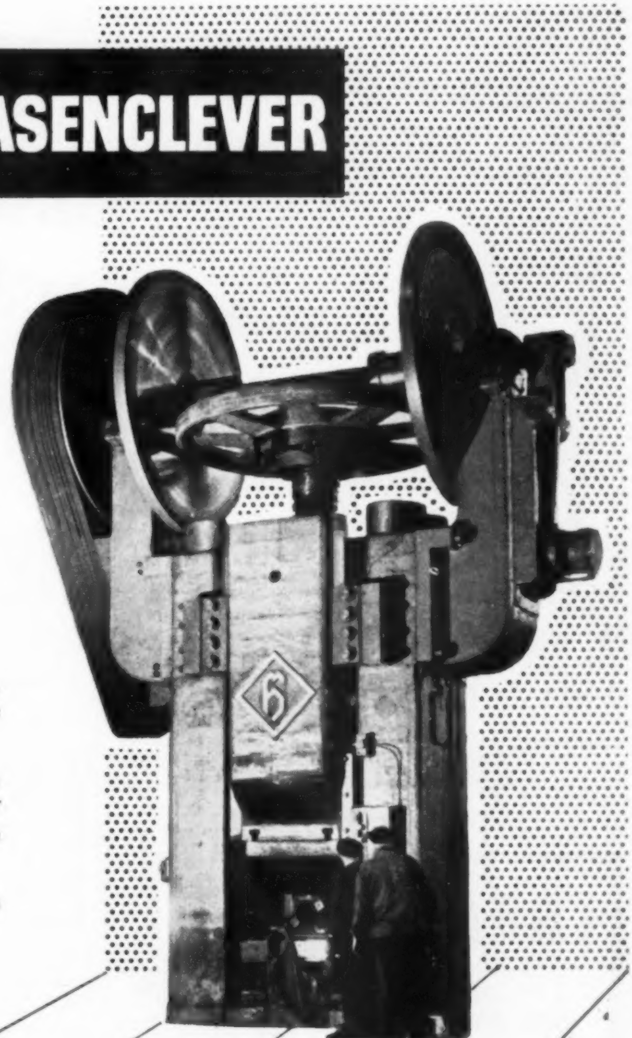

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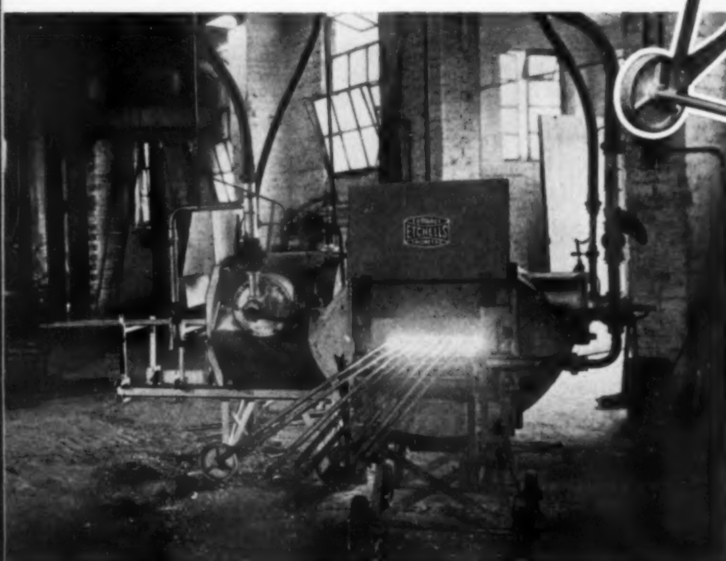

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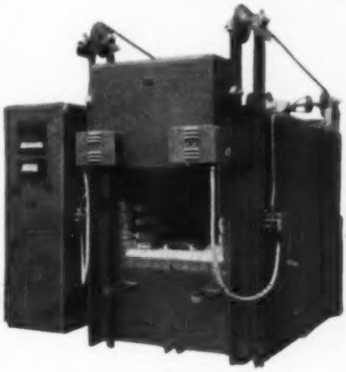

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